The Working Group on Lead

Report to the Ontario Minister of the Environment

STUDIES OF THE RELATIONSHIP OF ENVIRONMENTAL LEAD LEVELS AND HUMAN LEAD INTAKE

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August 1974

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REPORT OF WORKING GROUP ON LEAD

FOREWORD

Lead has been used by man for at least three thousand years and its many unusual properties have continued to ensure that, despite changing uses, it remains an important and useful item of commerce. In common with many other useful products lead, under certain circumstances, can be hazardous to health and this has been known for as long as man has worked with this metal.

With the development of modern science it became clear that, just as with all toxic materials, the amount of lead absorbed into the body and the duration of this absorption determined whether a person suffered ill effects from lead. The development of occupational medicine in the nineteenth century also demonstrated that it is possible to handle the most toxic of materials including lead if careful and unremitting attention is paid to certain elementary principles. With knowledge of these principles lead poisoning became a preventable disease although the application of the principles is often not easy in lead processing plants built many years ago or in areas of housing containing deteriorated lead painted surfaces.

Lead poisoning in adults is characterized by colicky abdominal pain, malaise, weakness of muscles (particularly those most used, eg., painters wrist drop) and anemia. In long continued severe exposure, which is now fortunately rare, permanent damage to the kidneys and nervous system may result. Significant hazards to the health of adults from lead have almost entirely been connected with the lead processing industry or industries using lead products

eg., lead paint and lead-containing gasoline additives.

In children not only is the clinical picture of lead poisoning different but the most usual cause has been the eating of flakes of lead paint from deteriorating older homes.

The early signs of lead poisoning are irritability, colicky pains and lethargy, which are not uncommon in children, and may be associated with relatively trivial self-limiting diseases. If, however, they do represent the early evidence of lead poisoning and are missed then the next series of events may be the late, or severe, stage of childhood lead poisoning with repeated vomiting, coma and convulsions.

The control of lead poisoning in employees in the lead industry and among inner city children in dilapidated housing has represented a large and serious problem to the various agencies concerned and it is only within the last few years that the situation has improved sufficiently to allow some resources being devoted to surveys of the lead levels of the general population. When such surveys have been carried out among people living close to lead smelters it has been found that the emissions of some lead smelters have not only caused raised air and soil lead levels but that residents close to such plants may also have elevated blood lead levels. Fortunately, in most instances these elevations of the blood lead levels have been small and have not resulted in any detectable effect on health but this has not been so in all cases as is mentioned in Section 3 of this report.

In Toronto the search for possible effects of secondary lead smelters on the surrounding population began in June of 1972 as the result of a complaint of dust from a secondary lead smelter falling on a back yard table. The dust was analyzed by the Ministry of the Environment and a high lead content was discovered. This finding resulted in a survey of blood lead levels of residents in the immediate neighbourhood by the provincial Ministry of Health and, because some of the residents had raised blood lead levels, the Medical Officer of Health of the City of Toronto was notified and the extensive joint studies set out in this report were undertaken.

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PREFACE

THE WORKING GROUP ON LEAD:

The Working Group on Lead was set up by the Ministry of the Environment as a focal point of the efforts of people working directly on the problems of lead contamination in Toronto.

The general objectives of the Working Group are:

1. To assess the data collected on lead levels near lead processing plants in Toronto and to determine the effect of these levels on public health.

2. To recommend studies and actions to be taken by the Ministry of the Environment.

In December, 1973, the Air Management Branch prepared a report of findings to date. The report was titled "Interim Report on Lead in the Environment in the vicinity of Secondary Lead Smelters in Toronto". The report was issued in late January, 1974 by the Chairman of the Working Group.

The Members of the Working Group are:

Chairman	Mr. K.H. Sharpe	Assistant Deputy Minister, Assessment and Planning, Ministry of the Environment
	Dr. G.J. Stopps	Senior Medical Consultant on Environmental Health, Health Standards Divison, Ministry of Health
	Dr. G.W.O. Moss	Medical Officer of Health, City of Toronto Department of Public Health
	Dr. T.W. Anderson	School of Hygiene, Faculty of Medicine University of Toronto
	Mr. L. Shenfeld	Supervisor, Air Quality and Meteorology Section, Air Resources Branch, Ministry of the Environment
	Dr. S.N. Linzon	Supervisor, Phytotoxicology Section, Air Resources Branch, Ministry of the Environment
	Mr. D.J. Ogner	Chief, Air Quality Assessment, Central Region, Ministry of the Environment
	Mr. H.M. Nelson	Senior Engineer Consultant, Occupational Health Engineering, Ministry of Health
	Mr. D. Bartkiw	District Officer, Toronto West Central Region, Ministry of the Environment
Secretary	Dr. R.M.R. Higgin	Head, Special Studies and Preventive Planning, Air Resources Branch, Ministry of the Environment

Counsel to the Group

Mr. M. Manning	Senior Crown Counsel (Civil Litigation) Ministry of The Attorney General, Government of Ontario
Mr. J.N. Mulvaney	Director, Legal Services Branch, Ministry of the Environment

The Group in the course of current investigations consulted the following experts:

Dr. J.J. Chisolm Jr.	Johns Hopkins University, Baltimore, Maryland
Dr. B.W. Carnow	University of Illinois, Institute of Environmental Studies, Chicago, Illinois

SUMMARY OF FINDINGS OF THE WORKING GROUP ON LEAD

Environmental Lead Levels Near Lead Processing Plant

After reviewing the data on lead levels in the air, dustfall, soil and vegetation near the 5 lead processing plants considered in this report,

> The Canada Metal Co. Ltd., 721 Eastern Ave., Toronto
>
> Toronto Refiners & Smelters Ltd., 28 Bathurst St., Toronto
>
> Eltra of Canada Ltd. (Prestolite Battery Division), 1352 Dufferin Street, Toronto
>
> ESB Canada Limited, 2301 Dixie Road, Mississauga
>
> Tonolli Company of Canada Ltd., 2414 Dixie Road, Mississauga

the Working Group on Lead finds that the operations of these plants have contributed, and still are contributing, to lead contamination of the environment in excess of the degree of contamination found in urban areas due to other industrial and automotive sources. Re-entrainment of particulate matter from the area surrounding the plants may, under certain meteorological conditions, contribute to measured lead levels, but is not the major source of lead.

The degree and extent of contamination varies with each local situation as does the type of emissions from the plant, but all plants have increased the amount of lead in the environment of people living in their locale. In some locations, the situation is greatly aggravated by the proximity of residences within the zone of most severe contamination. The potential for exposure to lead from such sources as contaminated soil, street dirt, house dust, vegetation and air and

the risk of inadvertent lead absorption are increased the nearer people reside to the plant.

The Working Group finds that there is a sufficient risk of lead exposure near the plants to warrant the application of all possible modern technology to limit emissions from processing operations. There is still a great deal of progress to be made before the necessary degree of control, maintenance and operating practices are attained. Improvements have been made in the last year at all plants.

Out of the research into lead levels in urban areas, particularly near highways, the Working Group also finds that environmental lead levels adjacent to expressways and major arterial streets represent a risk of increased lead exposure to persons living and working in these zones. This provides support for current programs to reduce lead emissions from motor vehicles.

Blood Lead Levels and Their Relationship to Lead Concentrations in the Environment

About 6500 persons in the City of Toronto have had one or more blood samples taken for lead analysis. The areas within which people have been sampled are in the vicinity of Toronto Refiners and Smelters Limited, Canada Metal Limited, Eltra of Canada, Limited (Prestolite Battery Division) and a Control Area.

Of those sampled, 206 individuals had blood lead levels equal to or exceeding 40 micrograms of lead per 100 millilitres of whole blood. These 206 persons have been offered a full medical investigation under the supervision of the

Hospital for Sick Children. Of these, 200 persons have availed themselves of the offer and 23 of them have been admitted to hospital for more intensive investigation.

About 875 of the 6500 persons sampled live in the Control Area which does not contain a lead processing plant and in this group only 3 individuals had blood lead levels of 40 micrograms or greater per 100 ml of blood. In the Toronto Refiners and Smelters Limited and Canada Metal Company areas the number of individuals with blood lead levels of 40 or above increases as the plant boundary is approached. The distribution of lead levels above 40 micrograms is more diffuse in the area of the Prestolite plant and the number of such persons shows a less clear-cut increase as the plant is approached although there are more such individuals when compared with the Control Area.

Although the level of lead contamination in the external environment tends to be relatively similar from one house to another in a particular area, the blood lead levels of residents in adjoining houses or even in the same house may be strikingly different. This finding would suggest that factors other than mere availability of lead in the environment are important in determining a person's blood lead level. An example of such a factor might be the tendency of children to play in dusty areas therefore being more likely to contaminate their hands, mouth and food with the lead in dust and soil. That such a difference in behaviour between adults and children may be important is illustrated by the difference in the percentage of children having elevated lead levels compared with the number of adults having such levels. For example, those persons sampled in the Canada Metal Company area showed about 16% of children 7 years old or younger had blood lead levels of 40 micrograms or above while only about 3.5% of adults above age 19 had such levels.

Of the pathways for environmental lead to gain access to the human body both inhalation and ingestion are possible in the urban environment. In the vicinity of the lead plants ingestion is probably the more important pathway for some children with their frequent opportunity for ingestion of dust, dirt and soil.

If inhalation of lead were the most significant pathway of lead absorption one might expect a more uniform distribution of blood lead levels within an area and between different age groups.

In addition to the large blood lead sampling program there has been a household environmental survey coupled with a detailed interview conducted by Toronto public health nurses and inspectors. The measurements of the household environment have included samples of paint, water, household dust, garden soil, etc., while the interview has covered such matters as age and number of occupants, occupation, children's habits, food habits, etc. The sampling of the population is continuing and re-sampling of all persons found to have blood lead levels above 30 micrograms is being carried out at regular intervals.

In reviewing the findings to date the following factors should be taken into consideration:

(a) At this time, data related to the pathways (dust, dirt, diet, air and water) of lead intake by individuals having elevated blood lead levels have not been analyzed.

(b) The medical significance of blood lead levels below those known to be associated with clinical lead poisoning is not accurately defined.

While overt classical lead poisoning has not been encountered in the present community studies, it is the responsibility of public health officials not only to attempt to prevent such cases but to take or recommend such steps as will protect the population from the toxic effects of lead. In Section 3 of the report these effects are discussed together with their relationship to local lead contamination from lead processing industries.

Since, as pointed out in Section 3, potentially harmful effects of lead can now be measured at blood lead levels much below those associated with classical lead poisoning, a somewhat arbitrary level of 40 micrograms of lead per 100 ml of whole blood has been selected by a number of individual toxicologists and authorities as a level above which the blood lead level should not be allowed to rise. While this figure applies particularly to children, similar biochemical changes can also be found in adults as the blood lead level rises above 40 micrograms.

In Toronto, in the Control Area, blood lead levels at or above 40 micrograms are rare, suggesting that the aim of maintaining the blood lead level of persons below 40 micrograms is realistically attainable.

The very large volume of data derived from the surveys in Toronto will take many months to analyze but it is felt by the Working Group on Lead that there is now sufficient agreement among the medical experts, coupled with a sufficient understanding of the pathways for individual lead absorption from other studies, to recommend action at this time.

RECOMMENDATIONS OF THE WORKING GROUP ON LEAD

Based on the findings to date, the Working Group recommends that the following courses of action be taken:

(1) All lead-bearing materials with a potential for contamination of the environment be shipped in closed containers or an equivalent method be used to prevent loss of lead to the environment.

(2) The unloading, movement and storage of such lead-bearing materials on the property of lead processing companies be conducted in such a manner that the material is totally enclosed and losses to the environment are prevented.

(3) The handling of such lead-bearing materials be conducted in enclosed buildings or by the use of enclosed conveying systems to prevent loss of lead or lead compounds to the outside.

(4) The processing of lead-bearing materials be controlled at source using best available technology to limit emissions to meet the proposed air quality standards and criteria of the Ontario Ministry of the Environment, which should be promulgated as soon as possible. The standard is 10 ug/m^3/30 min. average and the criteria are 5 ug/m^3/24 hour average and 2 ug/m^3/30/day geometric mean.

(5) Backup control equipment or devices must be provided so that control to meet the standard is maintained in the event of primary control equipment failure.

(6) Emissions of lead and lead compounds to the environment be continuously monitored by the companies to the satisfaction of the Ontario Ministry of the Environment and the records be made available to the Ministry on request.

(7) Regular programs for maintenance of all control equipment and for a high standard of housekeeping on company property be implemented by lead processing companies to the satisfaction of the appropriate government authorities.

(8) Regular inspection of the in-plant conditions, equipment and recording devices be maintained by the appropriate government authorities.

(9) Programs for surveillance of community blood lead levels and related home environment be continued by public health authorities.

(10) The lead levels in the air, soil, dust and vegetation in the vicinity of lead sources continue to be monitored by government authorities.

(11) Cleanup of soil, street dirt and house dust be carried out in the contaminated areas contiguous to the lead plants. These contaminated areas to be designated as the zones in which the lead content of the top two inches of soil lead content exceeds 1000 parts per million. Priority should be given to schoolgrounds and parks.

(12) Provision should be made to assist relocation of families with children from the vicinity of lead sources upon medical advice.

(13) Cleanup of residual contamination be required upon relocation or discontinuation of a lead processing operation resulting in a different land usage of the site.

(14) The Working Group also recognizes that the classical causes of high lead absorption in individuals due to sources such as domestic lead paint, lead waterpipes, lead from improperly glazed ceramics, etc., are present in Ontario and steps should be taken for their elimination by the appropriate authorities.

1. INTRODUCTION

1.1 Lead Occurrence, Properties, Uses[1, 2, 3]

Lead atomic weight 208, chemical symbol Pb, is a soft ductile metal melting at 327°C. Primary lead is manufactured from galena or sulphide ores. Lead is alloyed with antimony, copper and zinc and is a constituent of brass and bronze, solder, lead acid batteries; oxides are used in some paint and pigments. Tetraethyl lead is used to about 0.1% by volume to improve the antiknock properties of gasoline and lead is used in the manufacture of special glasses for colour television and other cathode ray tubes, in the manufacture of rubber hose, cable sheathing, radiation shielding, sound insulation and printing plates. These processes are described in more detail in section 1.3

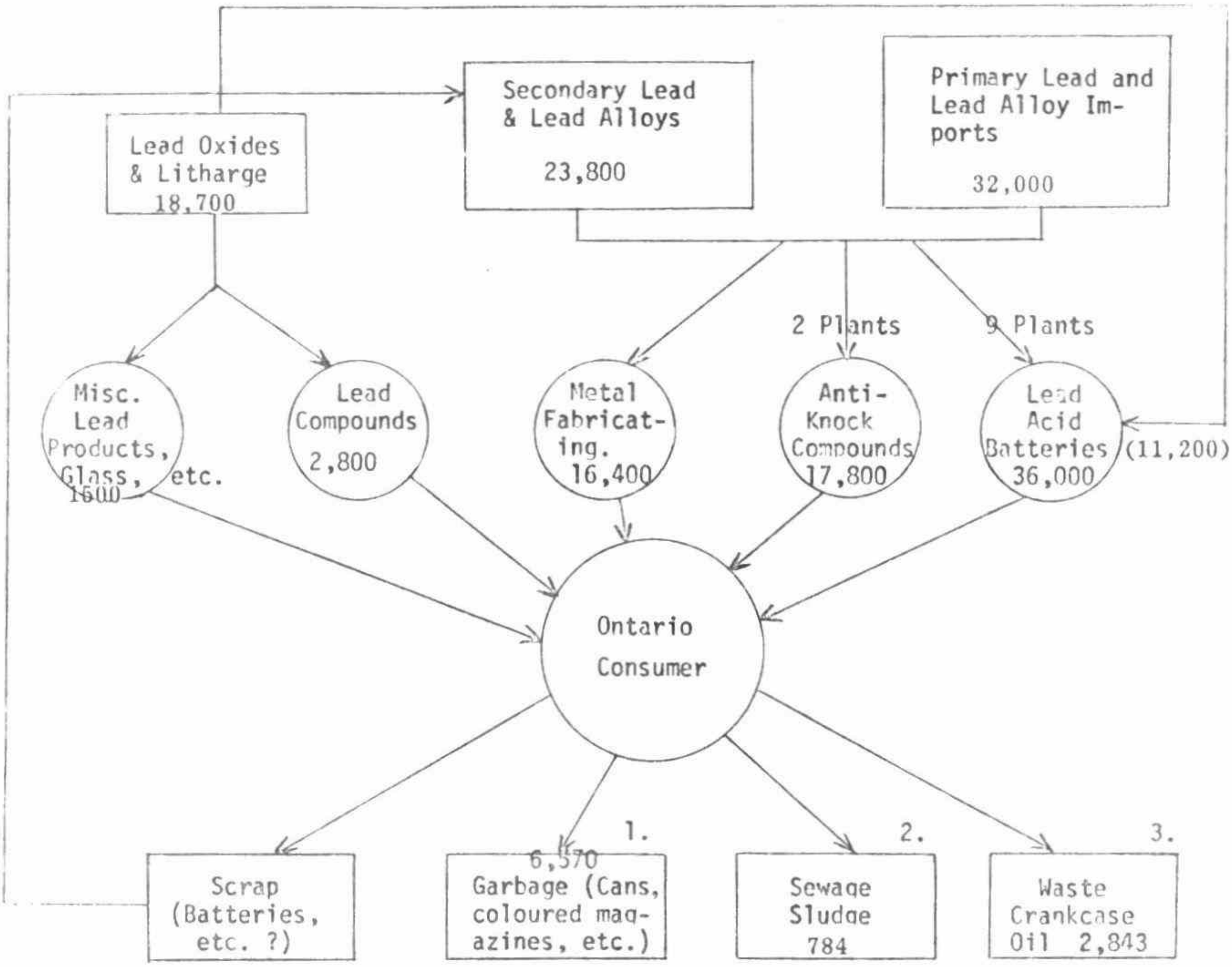
Lead is also present in many waste materials such as garbage (approx. 0.5% by weight), sewage sludge, waste crankcase oil, and a trace constituent of coal, oil and ferrous ores.

1.2 The Flow of Lead Through the Ontario Economy

Table 1.2-1 and Figure 1.2-1 show the flow of lead through the Ontario economy. There is no primary lead smelting in Ontario; primary lead is imported principally from British Columbia, New Brunswick and the U.S.A. Some lead ores are mined in the Timmins area but these are exported for smelting.

Secondary lead production is therefore relatively of greater importance and there are three secondary lead producers all in the Toronto area processing

Figure 1.2-1 FLOW OF LEAD THROUGH THE ONTARIO ECONOMY
Showing 1970 Estimated Figures in Tons



1. Based on 0.82 tons per capita/year and 1,000 ppm lead in refuse.

2. Based on 0.07 tons per capita/year and 1,400 ppm lead in dried sludge.

3. Based on lube oil consumption of 1,934,000 barrels/year in Ontario and 1% lead in waste oil (294 lb./barrel) from references 1 and 2.

[illegible] batteries or battery scrap. About 23,[illegible] produced by the three plants in 1970.

TABLE 1. ONTARIO LEAD BALANCE - 1970[3]

LEAD PRODUCTION IN TONS		LEAD CONSUMPTION [illegible]	
Primary [illegible] Production ([illegible] exported)	(11,960)	Primary Lead-Battery [illegible] facture.	[illegible]
Secondary Lead Production [1].	23,800	Secondary Lead-Battery [illegible] Manufacture	[illegible]
Lead Oxide Production [1].	13,700	Lead Oxide Con[illegible] Battery Manufacture	[illegible]
[illegible] Production	5,000	Manufacture of Anti[illegible] Compounds	[illegible]
Total Identified Ontario Production	42,500	Printing Industry [4].	[illegible]
Imported (&Unaccounted)	32,000	Metal Fabricating Indus-try	[illegible]
		Lead Pigments [3].	[illegible]
		Other Miscellaneous	[illegible]
		Total Consumption	[illegible]

1. Figure given in National Inventory of Sources & Emissions [illegible] (1970), Environment Canada.

2. Estimated from data given in National Inventory by prorati[illegible] on dollar value of battery shipments.

3. Estimated from data given in National Inventory by back-ca[illegible] from industry total emission using emission factor. (Total Canadian Production is in Ontario).

4. Estimated from Emission data in National Inventory.
   NOTE: A large portion is remelted.

5. Includes solder, brass and bronze alloys, cable sheathing [illegible] finished products. Consumption estimated from data in Na[illegible] [illegible]

1.3 SOURCES OF AIRBORNE LEAD EMISSIONS

1.3.1 Industrial Lead Processors[3, 4.]

(a) Secondary Lead Plants[4, 5.]

These plants conduct a large variety of operations reclaiming lead and producing lead alloys, solder and lead oxides from scrap lead. Because of the large quantities of material processed, the secondary lead smelter represents an intensive local source of lead emissions into the environment.

The operations at a secondary lead smelter can be divided into four parts:

(i) sorting and preparation of scrap for charging to furnaces

(ii) smelting of scrap in blast furnaces, reverberatory or rotary furnaces

(iii) refining and alloying of furnace metal in "kettles" and casting into ingots

(iv) production of various grades of lead oxides

Flow diagrams for typical smelting operations are shown in Figures 1.3-1 and 1.3-2.

(b) Emission Factors for Secondary Lead Operations

Both the Environmental Protection Agency in the U.S.A.[5] and Environment Canada[5] have published data on typical emissions from secondary lead operations. In addition the Ministry of the Environment has required emission tests performed on several sources.

[illegible]

TYPE OF OPERATION	PARTICULATE EMISSION (lb/ton)						LEAD EMISSION ([illegible])					
	UNCONTROLLED			CONTROLLED			UNCONTROLLED			CONTROLLED [illegible]		
	EPA	ENV.CAN	ONT.	EPA	ENV.CAN	ONT.	EPA	ENV.CAN	ONT.	EPA	ENV.CAN	ONT.
Blast Furnace	190	185		2.3	-		-			-	-	
Reverberatory Furnace	130	164		1.6	-		-			-	-	0.8-2.5#
Rotary Furnace	70	-		-	-		-			-	-	
Pot Furnace	0.8	0.26		neg.	0.26		-			-	0.26**	0.02-0.06#
Refining Kettle	-	-										

* Controls are generally fabric filters.

** Lead oxide - not lead.

\# Controlled by scrubber (85% efficiency).

NOTE: There are no published data related to fugitive emissions from the handling, crushing, transfer and storage of scrap materials and dross since these are almost impossible to quantify. Estimates of total plant contribution to lead in dustfall have been made (see sections 6.1.3 and 6.2.3)

(c) Fugitive Emissions

No matter how efficient the hooding and control system is, some fume will escape collection and will enter the building air and subsequently, be exhausted in the ventilation system or escape through open doors and windows.

The handling and sorting of scrap material, the crushing of batteries, and the handling of furnace dross are all sources of lead particles contributing mainly to dustfall. The experience of H.M. Alkali Inspectorate in the United Kingdom, as in Ontario, has been that these fugitive sources are the principal cause of problems with secondary lead smelters.[6, 9]

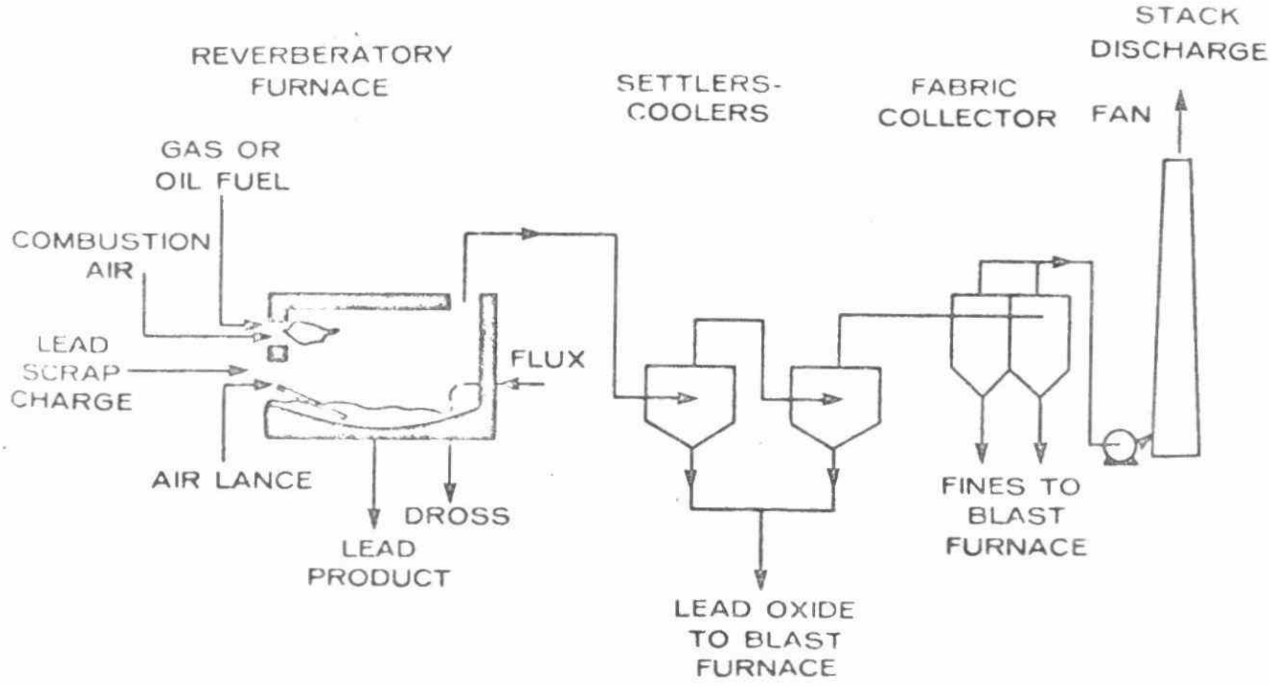


FIG. 1·3-1 Process flow sketch for Lead Reverberatory Furnace

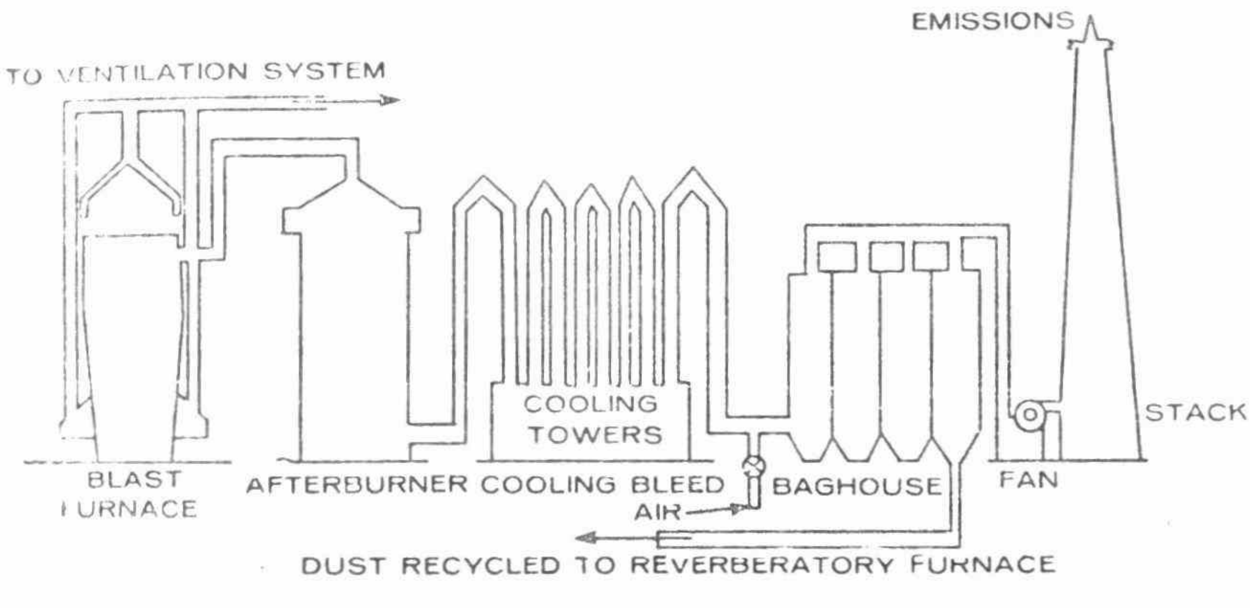


FIG. 1·3-1 Controlled Lead Blast Furnace, Afterburner and Baghouse

(d) Battery Plants [4,5].

There are nine large automotive battery plants in Ontario. Only one of these (Prestolite) conducts operations in the City of Toronto. A battery plant manufactures lead acid batteries for automotive and industrial use from pig lead, lead alloys and lead oxide.

The operations can be divided into 5 main operations:

1. Manufacture of plate grids and terminals
2. Manufacture of battery paste
3. Plate formation, drying and finishing
4. Assembly
5. Filling and charging

A flow diagram of a typical battery plant is shown in Figure 1.3-3.

(e) Airborne Emissions from Battery Manufacturing Operations

The major points of lead emissions from battery manufacture are:

- melting pots for casting machines
- lead oxide mills
- paste mixers
- plate brushers & trimmers
- terminal soldering (post burning)

With the exception of the lead pots there are no published emission factors for the operations listed above. The Province of Ontario has collected some preliminary data and these are presented in Table 2.

Figure 1.3-3

STORAGE BATTERY MANUFACTURE
FLOW DIAGRAM

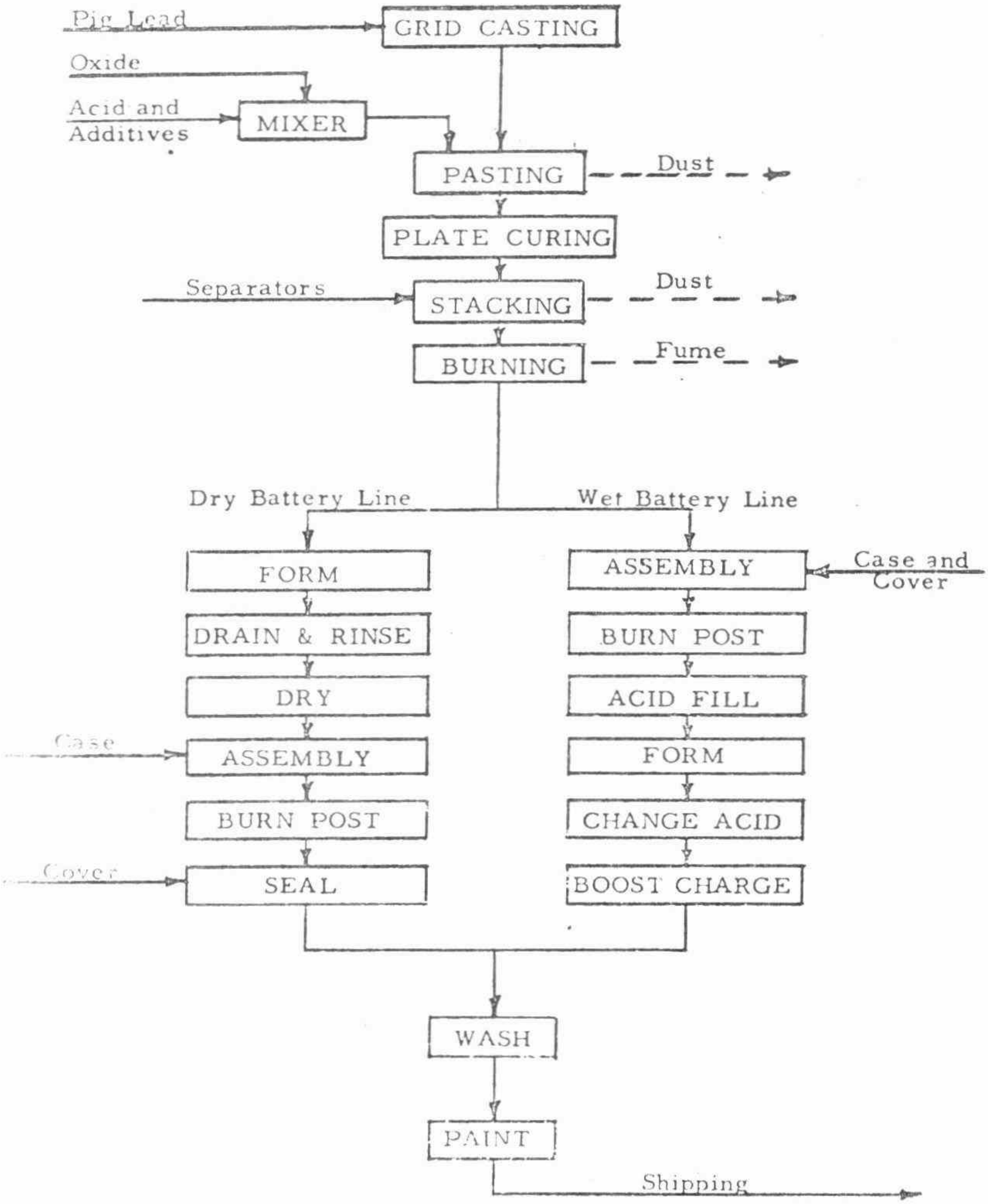


TABLE 2 LEAD EMISSIONS FROM BATTERY MANUFACTURING OPERATIONS

OPERATION		EMISSION OF LEAD & LEAD COMPOUNDS (LB.) (MEASURED)	REMARKS
Lead oxide mill	1.	.009-0.02 lb per ton of oxide	controlled by baghouse
	2.	0.25-0.3 lb per ton of oxide	cyclone and baghouse
Paste mixer		0.019-0.025 lb per ton of paste	controlled by scrubber
Grid casting		.0075-0.012 lb per ton melted	controlled by cyclone
Plate stacking brushing parting		0.17-0.27 lb per ton production not noted	controlled by baghouse
Post and element burning		0.004-0.014 lb per ton - production not noted	controlled by baghouse

Control of particulate emissions is generally achieved by the use of fabric filters or scrubbers. Acid mist and fumes are controlled by aqueous or caustic scrubbers.

1.3.2 Other Industrial Sources of Lead Emissions[3, 4.]

(a) Brass & Bronze Foundries

Lead is a significant component of many brasses and bronzes, particularly those used in the manufacture of plumbing fixtures, collapsible tubes and pewters. Emissions arise from the melting, casting, machining and finishing operations and may require control depending on the individual situation.

(b) Ammunition Manufacturing

Rifle and shot gun ammunition is made from lead and lead azide is used as a detonator. Lead is melted in pot furnaces and cast into bullets or sprayed into water to produce shot. Principle emissions are from the melt pot and this may require control.

(c) Lead Cable Sheathing and Hose Manufacture

Underground electrical cables are often sheathed in lead to prevent corrosion damage. Rubber hoses are covered in lead to protect the surface during vulcanising and bending of the hose and is afterwards removed. The lead pots used for holding and remelting lead in both processes may require control.

(d) Pigment Manufacturing

Lead oxide is the starting point for the manufacture of certain pigments used as a constituent of printing inks and some special purpose paints. Typical pigments are lead dichromate, Pb CrO_4 (orange) and lead molybdate, Pb MoO_4 (green). The principle sources of emissions are the handling and storage of the lead oxide, mixing and reaction vessels, the spray drier and product mills. All of these operations require control and it is economic to recover as much material as possible. Fabric filters, with or without cyclones as precollectors, are usually employed.

(e) Manufacture of Leaded Glasses[8]

Lead glass has come into widespread use for cathode ray tubes of all types. The glass is optically superior and also cuts down the intensity of potentially harmful rays emitted by the electron gun in the cathode ray tube. With the inception of colour televisions employing 3 electron guns, there has been a need to produce glasses containing a much higher percentage of lead.

Since a glass furnace operates at relatively high temperatures (1800-2200°F) well above the boiling point of lead and lead oxide, a very high proportion of the lead in the feed to the furnace is lost. It may be necessary to add 25% by weight of lead oxide to the mix in order to attain 10% lead in the final product. This constitutes a major source of airborne lead emissions and requires control. In addition, handling and mixing of lead oxide requires control of pneumatic conveying systems and storage silos.

(f) Lino-type Setting

The printing industry employs lead in the lino-type setting process which is the most commonly used method for printing of newspapers. The principle emissions arise from the melting/holding pot used to supply the typesetting machine. There is also some question regarding organo lead emissions during remelting of lead contaminated with printing inks.

(g) Paint Industry

Although domestic lead containing paints are low lead in Canada and the U.S.A. and 'lead-free' paints are used for nursery furniture and toys; lead paints are still used

as rustproofing primers in industrial applications.

During the manufacture of the paint, emissions of lead oxides and other lead compounds can arise mainly during the handling and milling of the pigment and during mixing of the resin vehicle and pigment.

These emission sources require control and scrubbers or fabric collectors are usually employed.

(h) Manufacture of Antiknock Compounds [8]

Tetraethyl lead (and tetramethyl lead) are widely used to increase the octane of automotive gasolines. Burning of these gasolines is a major source of urban lead contamination (see Section 2.2). During the manufacture, pig lead is melted in pot furnaces and then alloyed with metallic sodium to produce a lead - sodium alloy. This alloy is alkylated with ethylchloride (methylchloride) in an autoclave and the residue steam distilled to recover tetraethyl lead (tetramethyl lead). The still residue is dumped into a sludge pit and fed to a drier from which additional tetraethyl lead (tetramethyl lead) is recovered. The dried sludge is fed to a reverberatory or open hearth furnace to recover lead which is used in the process. Sodium compounds are skimmed off in the dross.

These operations give rise to both particulate lead and organic lead emissions. Particulate lead emissions arise from the recovery furnace and are usually controlled by the use of wet scrubbers. Organic lead emissions arise during

[illegible] of the [illegible] recovery from the [illegible] and sludge drier. In addition, some emissions are suspected to occur during the mixing, blending, storage and shipping of the finished antiknock compounds.

1.3.3 Automotive Lead Emissions

Lead alkyl compounds, principally tetraethyl lead, are added to gasoline to raise the octane rating of the gasoline and are particularly necessary in modern high compression engines. Lead additives are blended into the gasoline at the end of the refining process. An average metallic lead concentration is 2.7 grams/U.S. gallon in premium and 2.3 grams/U.S. gallon in regular gasoline (3.4 and 2.9 grams/imp.gallon). Most of this lead is emitted in the exhaust gas. A small amount deposits on valve surfaces and is reported to have a beneficial effect on engine life and some 3% goes into the engine oil. Removal of lead in gasoline is the subject of major controversy at this time, particulary in the U.S. due to the Environmental Protection Agency's lead phase-out regulations.

Certainly removal of lead in gasoline will mean higher aromatic content of straight run gasolines with an accompanying loss in yield. There is also some evidence that hydrocarbon emissions are increased by using unleaded gasolines. The main driving force for removal of lead from gasoline is that the catalytic convertors required to meet Federal U.S. standards for hydrocarbon and nitrogen oxide emissions are contaminated and rendered useless by lead in the exhaust gas. The use of lead traps is under active investigation by the producers of antiknock compounds, as are alternatives such as methylcyclopentadienyl manganese tricarbonyl (M.M.T.).

It has been estimated that in 1968, 250,000 tons of automotive generated lead were emitted into the atmosphere in the United States. A similar estimate for Canada in 1970 was 14,083 tons.[4] In the same report, a figure of 5,125 tons was also quoted for Ontario. Fuel consumption figures give a total emission of about 1,760 tons/year in Toronto.

The Lead emitted from automobiles is mainly in the size range of 0.1 - 2 microns with some larger particles which fall out rapidly being generated as a result of flaking of deposits from the engine and exhaust system.

The effects of lead emissions on ambient air lead levels in urban areas have been extensively documented and are discussed further in Section 2.

The amount of airborne suspended lead in urban atmospheres has been reported to average about 0.6 micrograms/m^3 in cities with populations less than 200,000 and to reach average city wide levels of 1.5 ug/m^3 for cities with populations exceeding 1,000,000.

Local ambient air values close to highways can reach values greatly in excess of these figures, but measurements indicate that there is a rapid drop-off with distance from the highway.

The subject of the automotive contribution to ambient air levels in urban areas is discussed in greater detail in Sections 2.2 - 2.4. The health effects of automotive lead emissions are still the subject of considerable controversy and data compiled by the Environmental Protection Agency and

a recent paper indicating a link between distance from highways and blood levels is discussed in Section 3, concerning standards.

1.3.4 Inadvertent Lead Emissions from other Major Sources[4]

Lead occurs as a trace element in many naturally occurring rocks, ores and fuels. During processing or combustion of these materials, lead is emitted into the air in the form of dust or finely divided suspended particulate matter.

The major identified sources of indirect lead emissions in Ontario are as follows:

(a) Production of Nickel and Copper

Lead is present in the indigenous pyrhotite ores found in Ontario during the smelting process for the production of concentrates the lead is emitted. Particulate test data from Sudbury indicates a lead content of 1.2% in the emitted particulate after the control equipment giving an approximate yearly emission of about 20 tons/year.

(b) Iron & Steel Production

Lead is a very minor constituent of iron ores produced in Ontario. The major lead emissions occur during the sintering and blast furnace operations for the production of iron.

Data reported by Environment Canada[4] indicate that ambient lead emissions from iron production in Ontario amounted to a total of 1,475 tons in 1970 of which about 1,000 tons a year were attributed to Hamilton, Ontario. Emissions from steel production were estimated at 86 tons/year mainly in Hamilton.

These figures are only estimates and are not supported by high ambient air lead levels close to the steel mills.

(c) Ferro Alloy Production

Estimates of lead emissions from trace amounts of lead in the materials used for the production of ferro-silicon and ferro manganese alloys range of 0.5 - 1% of the emitted particulate giving a figure of 35 tons/year in Welland.[4]

(d) Ferrous Foundries

The lead content of dust emitted from ferrous foundries has been reported to range from 0.5 - 2.0% by weight. Environment Canada [4]have estimated emissions in Ontario to total 16.8 tons/year in 1970.

(e) Cement Manufacture

The Environmental Protection Agency[5] have estimated that particulates emitted from cement plants contain about 450 parts/million of lead. Using this figure, Environment Canada have estimated lead emissions in Ontario from cement manufacturing to total 57.8 tons/year.

(f) Zinc Production

Environment Canada has estimated emissions of lead from the zinc production industry to be about 12 lb/ton of zinc product, giving a total emission from the Port Maitland plant of about 5 tons/year.

1.3.5 Inadvertent Emissions of Lead from Waste Disposal

(a) Incineration of Garbage

Municipal garbage contains lead with reported values in the range 0.06 to 0.1 per-cent by weight. The lead is due to soldered cans, coloured magazines and some glass.

The incineration of this garbage gives rise to flyash and bottom ash both of which contain trace amounts of lead.

The lead content of flyash has been measured by consultants for the Ontario Ministry of the Environment as 0.5% by weight and the total uncontrolled flyash to average 23 lbs/ton of garbage incinerated giving a lead emission factor of 0.12 lbs/ton of garbage incinerated.

The lead is removed along with other particulates in gas cleaning equipment such as scrubbers and electrostatic precipitators.

(b) Incineration of Waste Crankcase Oil

Waste crankcase oil has been reported to contain about [illegible] by weight of lead

resulting from absorption of the gasoline antiknock decomposition products.[4] Waste crankcase oil is used as a cheap source of heat usually blended with straight-run conventional fuel oils. Most of the lead contained in the fuel is emitted with the combustion gases. Because the amounts are small this lead does little more than add slightly to the urban background level.

(c) Incineration of Sewage Sludge

Dried sewage sludge is reported to contain about 1400 ppm of lead. The incineration of this sludge lead to particulate emissions containing trace amounts of lead. It is estimated that 0.2 lb of lead are emitted per ton of dry sludge incinerated. Conventional particulate removal equipment is satisfactory for removal of both particulates and lead.

INVENTORY OF LEAD EMISSION SOURCES IN METROPOLITAN TORONTO & AREA

SOURCE	ESTIMATED YEARLY EMISSION (TONS)			ESTIMATED MAX. HOURLY EMISSIONS	
	Env.Can/1970	AMB/1970	Env.Ont/1974	lb/hr. max. Emission	Maximum Calculated 30 Minute Concentration
Canada Metal Company	14.25	30.5	8.0	3.3 (C)	
Rotocast Limited	-	2.2	2.2	4.3 (C)	
Toronto Refiners and Smelters Limited	12.0		10.1 (ST)	3.2 (ST)	
R.L. Hearn Generating Station			0.025 (C)	0.01	
Lakeview Generating Station			0.23	0.06	
Prestolite			7.2 (C)	3.6	
Automotive Traffic	-		1760 (C)	402	
Federated Genco			1.8 (C)	4.0	21
Commissioners St. Incinerator		6.4		1.5	0.5 (30 min.)
Grand Avenue, Mimico		1.3		0.3	0.25 (30 min.)
Symes Road Incinerator		5.4		1.3	0.25 (30 min.)
Ingram Drive Incin.		3.1		0.7	0.15 (30 min.)
Dufferin St. Incin.		3.2		0.7	0.25 (30 min.)
Forest Hill Incin.		0.6		0.2	0.20 (30 min.)
Wellington St. Incin.		3.4		0.3	0.15

INVENTORY OF LEAD EMISSION SOURCES IN METROPOLITAN TORONTO & AREA

(Continued)

SOURCE	ESTIMATED YEARLY EMISSION (TONS)			ESTIMATED MAX. HOURLY EMISSIONS	
	Env.Can/1970	AMB/1970	Env.Ont/1974	lb/hr. max. Emission	Maximum Calculated 30 Minute Concentration
Electric Storage Battery, Scarborough.	-	-	0.6	0.4	
Electric Storage Battery, Mississauga.	-	9.3	2.4 (0.8)	0.7 (.31)	
Tonolli, Mississauga	6.10	5.65	5.6	1.5	15
Globelite Batteries	-		0.3	0.4	11
Ingot Metal Company	-	-	9.6	-	
Anaconda Brass	-			0.2	
[illegible]inion Colour	-		6.4	1.6	
[illegible] Stamp & Stencil			0.016	-	
[illegible]als & Alloys			0.3	-	
[illegible] Meters			0.25	-	
[illegible] Canada			0.27	-	
Toronto Star			0.7	-	
Globe & Mail			0.6	-	

TABLE 2.

INVENTORY OF LEAD EMISSIONS IN ONTARIO

(From National Inventory of Sources and Emissions of Lead (A-70) - Environment Canada)

Type of Source	# in Ont.	lb/ton of lead (unless otherwise designated) Emission Factor	Estimated Yearly Lead Emission in Tons
Lead Producing Industry			
1. Mining of lead-bearing ores:			
a) underground	1	2.025	2.32
b) open-pit	1	2.05	9.58
2. Milling & production of lead concentrate	1	2.9	3.32
3. Secondary Lead Production	3	1.64 - Reverb Furnace 1.85 - Blast Furnace 0.26 - Melting Kettle	32.35 (AMB Estimates Higher)
Lead Processing Industry			
1. Battery Manufacturing	11	0.14 - (Oxide bought) 0.20 - (Oxide made)	2.17 (AMB Estimates Higher)
2. Litharge Production	1	0.12	0.3 (AMB Estimates Higher)
3. TEL & TML Production	2	7.25	64.5
4. Lead Pigments	2	0.0075	0.1 (AMB Estimates Much Higher)
5. Lead Glass	1	-	94.5 AMB Stack Test
6. Metal Fabricating Including Brass, Bronze and Solder		11 - copper alloys 0.26 - solder 4 - other operations	23.0
Combustion Processes			
1. Power Plants - Coal		0.0105 lb/ton coal	1.1 (Controlled 97.5%)
2. Coke Production	3	0.032 lb/1000 tons coal	0.10
3. Oil Combustion		12 lb/1000 tons oil	26.8 (Heavy Oil)
4. Wood Combustion		1.7 lb/1000 tons wood	3.68
Gasoline Consumption			
1. Automotive	-	1500 lb/ton of lead in fuel (aver. 3 grams/imp. gallon)	5125
2. Aviation	-	1500 lb/ton lead in fuel	27.3

Cont'd.......

INVENTORY OF LEAD EMISSIONS IN ONTARIO (Cont'd)

Type of Source	# in Ont.	lb/ton of lead (unless otherwise designated) Emission Factor	Estimated Yearly Lead Emission in Tons
Inadvertent Emissions			
1. Zinc Production	1	12 lb/ton of lead 0.028 - 0.22 lb/ton zinc	4.9
2. Copper/Nickel Production	2	437 lb of lead/ton of lead in concentrate	316.0 (AMB Stack Test - 1.2% of Particulate)
3. Iron Production	3	4.68 lb/ton metal process.	1474.3 Controlled Emission
4. Steel Production	4	0.14 lb - 0.18 lb/ton produced.	86.1 Controlled Emission
5. Ferro Alloy Production	1	0.9 - 1.4 lb/ton produced	35.35 Uncontrolled Emission
6. Iron Foundries	59	0.2 lb/ton processed	16.8
7. Cement		0.11 - 0.15 lb/ton of cement.	57.8
Waste Disposal			
1. Refuse Incineration	5	0.15 lb/ton burned	16.44 Controlled Emission
2. Sewage Sludge Incineration	2	41.5 lb lead/1000 tons burned.	1.36 Controlled Emission
3. Waste Oil Incineration		20 lb/ton of oil	76.4
Other Minor Sources			
1. Automobile and Can Soldering, etc.	6	0.26 lb/ton melted 4.16 lb/ton grinding	2.7
2. Printing	34	0.26 lb/ton melted	14.9
3. Insecticide Application		500 lb/ton of lead in insecticide	1.81
TOTAL FOR ONTARIO			7521 = 5125 automotive 2396 other

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2. BACKGROUND LEVELS OF LEAD IN THE ENVIRONMENT

2.1 Natural Background Levels[1,2,3,4]

Lead bearing minerals occur naturally in the earth's crust; galena contains some 7-10% lead, morphite contains lead phosphate, crocoisite lead chromate anglesite lead sulphate and cerussite lead carbonate. Some of this lead is weathered and leached into natural waters and enters the food chain. Some lead in soil and groundwater can also be taken up by agricultural crops although lead is relatively immobile and uptake is very slow.

Table 2.1-1 shows a list of typical lead natural background levels in air, soil, vegetation and food. There is probably some contribution included from global increase in environmental lead due to the activities of man.

TABLE 2.1-1 Typical "Natural" Background Lead Levels (From Airborne Lead in Perspective N.A.S.)

Water	1 - 10 ug/litre
Soil	2 - 200 ug/gram
Dustfall	0.2 mg/m^2/30 days (0.0006 $tons/mile^2$/30 days)
Precipitation	1 mg/m^2/30 days (0.003 $tons/mile^2$/30 days)
Food:	
Condiments	0 - 1.5 ug/gram
Fish & Seafood	0.2 - 2.5 ug/gram
Meat & Eggs	0 - 0.37 ug/gram
Grains	0 - 1.39 ug/gram
Vegetables	0 - 1.3 ug/gram
Milk	0
Air	0.05 - 0.5 ug/m^3

"Natural" lead in the food chain is important in that dietary ingested lead gives a base level of human lead intake as indicated by human blood lead levels.

The assumption is usually made that an average adult will ingest about 300 ug of lead/day from food and water of which a relatively small portion is retained[5].

These are only average figures; however, it has been shown that humans, remote from all anthropogenic sources of lead, can have mean blood lead levels from 15 to 23 ug/100 ml of lead in blood.

TABLE 2.1-2

Lead Levels in Various Populations*

Location	Subjects	Mean Pb Conc. mg/100 g Blood
Alpine County, Calif.**	37	0.013
New Guinea	67	0.013
Philadelphia Suburbs**	81	0.013
East Africa	63	0.015
Bechuanaland	63	0.017
Peru	39	0.018
Los Angeles Police**	155	0.021
Cincinnati**	140	0.023
Marshall Islands	33	0.023
Brazil	11	0.023

* Stopps, G.J.: Discussion presented at American Petroleum Institute Division of Refining Meeting, Los Angeles, May 16, 1967, "Du Pont Company's Investigations into the Health Effects of Lead".

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2.2 Review of Some Reported Data on Environmental Lead Levels in Urban Areas

2.2.1 Suspended Lead Levels

Lead levels in urban air are generally at least an order of magnitude above those normally found in remote areas due principally to automotive lead emissions with a minor contribution from other fuel combustion processes and small industrial operations.

Data obtained in the United States are presented in Table 2.2-1. These indicate that average urban suspended lead levels in large U.S. cities are in the range 2.1 - 5.7 ug/m^3. No reference is made to the number of stations and the location of these in each city so that the data are merely an indication of the range of suspended lead levels in urban areas.

TABLE 2.2-1 Maximum Quarterly Composite Lead Levels Exceeding 2.0 Micrograms Per Cubic Meter[a]

Location	Maximum Quarterly Composite
Oklahoma City, Oklahoma	2.1
Baltimore, Maryland	2.1
Miami, Florida	2.1
Kansas City, Kansas	2.2
Fort Worth, Texas	2.3
Cleveland, Ohio	2.3
Springfield, Massachusetts	2.4
Shreveport, Louisiana	2.4
Las Vegas, Nevada	2.4
Richmond, Virginia	2.6
New York, New York	2.8
Houston-Galveston, Texas	2.8
Seattle, Washington	2.9
N.W. Nevada	3.0
Detroit, Michigan	3.2
Denver, Colorado	3.4
Salt Lake City, Utah	3.6
Chicago, Illinois	3.6
El Paso, Texas	3.6
Philadelphia, Pennsylvania	3.6
Phoenix, Arizona	3.9
San Francisco, California	3.9
Puerto Rico	4.2
San Diego, California	4.2
Fairbanks, Alaska	4.8
Dallas, Texas	5.2
Los Angeles, California	5.7

a/ Source: NASN data on file at the Division of Atmospheric Surveillance, National Environmental Research Center, Environmental Protection Agency, Research Triangle Park, North Carolina.

Annual Mean Concentrations of Atmospheric Lead June 1961 Through May 1962[a]

Lead Concentration, ug/m^3

Site	Cincinnati	Los Angeles	Philadelphia
Commercial	1.7	2.9	2.2
Industrial	1.8	2.3	2.2
Residential	1.1	2.0	1.1
Rural	0.9	2.8	0.9
All Stations	1.4	2.5	1.6

a/ Adapted from "Survey of Lead in the Atmosphere of Three Urban Communities," reference 6.

Data obtained in studies in Detroit, New York and Los Angeles by General Motors[7] showed that suspended lead levels varied widely with the [illegible] occurring close to freeways in Los Angeles and with lower levels occurring in more residential areas. The highest annual average reported was 11.2 ug/m^3 at 5 metres from the Harbor-Santa Monica Freeway Interchange in Los Angeles. The highest 24-hour value recorded was 18.4 ug/m^3.

It can be seen that extremely high values of suspended lead can occur close to highways in urban areas.

In a study undertaken by Rutgers University[8] in New Jersey air samples collected at varying distances from highways indicated a relationship between the suspended lead levels and both distance from the highway and traffic density.

The data were fitted by the regression equation:

$$y = 2.049 - 9.327\, x_2 + 20.962\, x_2^2 + 1.573\, x_3 + 10.992\, x_3^2 - 0.391\, x_1 x_2 + 1.654\, x_1 x_2^2$$

y = suspended lead level ug/m^3

$$x_1 = \frac{(\text{vehicles/day} - 42{,}000)}{1{,}000}$$

$$x_2 = \frac{(\text{distance} - 172.4)}{1{,}000}$$

$$x_3 = \frac{\text{week no.} - 26.5}{100}$$

The highest value recorded was a 7-day average value of 15.6 ug/m^3 at 30' from a highway with 58,000 vehicles/day. The levels fell off rapidly with distance, reaching 50% of the maximum by 150' and approaching the background level at 300' from the highway.

A recent study undertaken by Crocker Neuclear Laboratory, U.C.D.,[9] in Los Angeles confirmed that there was high levels of gasoline generated air contaminants, including lead close to a freeway. The Freeway configuration was found to have an important influence on suspended lead levels.

TABLE 2.2.1-2

ATMOSPHERIC LEAD CONCENTRATIONS

Metropolitan Area	Site	Area Type	Distance from Nearest Traffic - Meters	Number of Samples	Lead - ug/m^3 Annual Average	Maximum	Minimum
Detroit	Lodge-Ford Freeway Interchange	Freeway	5	10	8.9	11.8	6.2
	Grand Circus Park	Commercial	5	5	4.2	5.4	2.5
	GM Technical Center	Residential	150	5	1.2	1.5	1.0
	Over-all Detroit			20	4.8	11.8	1.0
New York	Herald Square	Commercial	2	15	7.9	13.0	3.7
	Columbus Circle	Commercial	3	12	5.3	7.6	2.8
	Queens Expressway Interchange	Freeway	75 from freeway 2 from residential street	12	3.6	9.4	1.6
	Queens Residential	Residential	2	4	2.7	3.0	2.4
	Scarsdale	Residential	2	4	1.7	2.1	1.0
	Over-all New York			47	4.1	13.0	1.0
Los Angeles	Pico Boulevard	Commercial	4	19	7.5	15.7	2.9
	Harbor-Santa Monica Freeway Interchange	Freeway	5	11	11.3	18.4	5.3
	Santa Monica	Residential	6	11	3.6	5.6	0.4
	Monrovia	Residential	20	11	4.3	10.8	1.8
	Over-all Los Angeles			52	7.6	18.4	0.4
Area Types:	Freeway			33	7.8	18.4	1.6
	Commercial			51	6.8	15.7	2.5
	Residential			35	3.1	10.8	0.4

TABLE 2.2.1-3

YEARLY MINIMUM, MAXIMUM, AND AVERAGE CONCENTRATION OF LEAD PER CUBIC METER AT SAMPLING STATIONS

Distance from highway in feet	1967-68				1968-69			
	Cars per 24 hrs.	Min.	Max.	Av.	Cars per 24 hrs.	Min.	Max.	Av.
30	19,750	1.5	3.3	2.12	19,850	1.1	5.3	2.37
100		1.0	2.3	1.56		0.8	3.0	1.62
150		0.8	2.4	1.36		0.7	3.0	1.48
250		0.7	1.7	1.11		0.6	2.5	1.18
500		0.6	1.5	0.93		0.5	2.5	1.02
30	44,750	2.4	6.8	4.34	44,900	2.9	7.0	4.59
100		1.6	4.8	3.09		1.9	6.4	3.31
150		1.6	4.6	2.72		1.5	5.0	2.84
250		1.3	4.2	2.42		1.3	5.7	2.68
500		0.9	3.7	1.99		0.9	4.6	2.11
30	46,800	3.8	13.0	7.45	47,200	2.2	6.2	4.55
100	3% grade	1.6	7.0	3.75	level	1.4	5.4	2.84
150	accelerating	1.4	6.1	3.24		1.5	4.8	2.59
250	area	1.2	4.7	2.67		0.7	4.0	2.25
1750		0.6	3.0	1.36		0.6	2.9	1.46
10	58,050				58,050	4.3	15.6	10.10
30		4.1	9.5	6.14		3.1	9.9	6.60
100						2.4	7.3	3.99
150						1.7	5.7	3.21
250		1.3	4.1	2.42		1.5	5.3	2.65
500		1.1	3.6	2.05		1.7	4.7	2.16

Level of Pavement Relative to Grade	Wind	Lead Levels/5,000 vpd
-30 ft.	Traverse or Parallel	0.3 $\mu g/m^3$
0 ft.	Traverse	1.4 $\mu g/m^3$
+20 ft.	Traverse	3.1 $\mu g/m^3$

Lead levels at 330 ft. from an elevated section of freeway reached a maximum of 10 $\mu g/m^3$/24 hours with peak vehicle densities of 25,000 vehicles per hour.

2.2.2 Lead Bromine Ratio and Particle Size Distribution of Lead from Automotive Sources

The Rutgers University study also measured the particulate matter and lead size distributions adjacent to a highway with 47,000 vehicles/day. It was found that there was a higher portion of larger particles close to the highway, but that most of the lead was in a size range below 2 μm equivalent diameter.

		Percent Lead		
Impactor Stage	Particle Size μm	30'	250'	1,750'
1	> 14	7.1	6.2	2.1
2	6.5 - 14	6.4	6.5	4.3
3	3.5 - 6.5	9.7	10.7	9.7
4	1.6 - 3.5	10.8	11.6	15.6
5	< 1.6	66.0	65.0	68.3

The U.C.D. study also found that nearly all of the lead and bromine were in a size range below 5 μm with a substantial portion less than 0.5 μm.

The bromine/lead ratio of the particulate was less than the ethyl fluid ratio of 0.40 and averaged 0.33.

Studies conducted in the San Francisco Bay Area[10] using Andersen cascade impactors confirmed most of the lead from automotive sources was in the size range below 1.76 um and that the bromine/lead ratio was smaller than the ethyl fluid ratio of 0.4 (a value of 0.25 ± 0.05 was obtained). A strong correlation was again found between automotive lead and carbon monoxide adjacent to highways (r = 0.88).

2.2.3 Lead in Dustfall & Dust

Levels of dustfall or settleable particles vary widely with the highest values being found in heavily industrialized areas.

The lead content of the dustfall is important because the settleable lead particles contribute to contamination of soil of household and roadside dust, vegetation, snow and due to runoff from streets and melting snow to lead in water.

There are few published data on general levels of lead in dustfall in urban areas. Most data pertains to the contamination of roadside soil and vegetation by settleable particles from automotive exhausts. Some dustfall data have been reported for areas near secondary lead smelters in Finland[11].

Lead in dust on horizontal surfaces has been measured in some studies and are summarized in Table 2.2.3-1.

TABLE 2.2.3-1[1]

Site Location	Lead Content of Dust
Urban residential street	1,636 µg/gram average
Urban commercial street	2,413 µg/gram average
Urban industrial street	1,512 µg/gram average

Levels of lead in dirt adjacent to old frame houses have been reported to reach values as high as 2500 µg/g two feet from the houses with values up to 600 µg/g at ten feet from the houses.[12]

Levels of dustfall in the vicinity of two small secondary lead smelters in Tikkurila were reported to range from 0.05 grams/m^2/30 days to .2 grams/m^2/30 days with the highest level being recorded close to a smelter which operated without controls for a period of 10 years.[11]

An average of 73 percent of homes surveyed in the United States had lead levels in excess of 2000 µg/cm^2 on at least one accessible surface.[13]

2.2.4 Lead in Soils and Vegetation

Soils

As quoted, the naturally occurring lead content of soils is in the range of 2-200 ppm.

Numerous studies have been made of soil lead levels along highways. The following are the data of Lagerwerff and Specht:[14]

Site	Vehicles/Day	Distance	Lead Content of Soil (ug/gram dry wt.) 0 - 5 cm	5 - 10 cm	10 - 15 cm
1	20,000	8 metres	522	460	416
		16 metres	378	260	104
		32 metres	164	108	69
2	48,000	8 metres	540	300	98
		16 metres	202	105	60
		32 metres	140	60	38
3	7,500	8 metres	242	112	95
		16 metres	140	104	66
		32 metres	61	55	60
4	23,000	8 metres	150	29	11
		16 metres	101	14	8.2
		32 metres	55	10	6.1

The lead content of some soils in urban areas can be extremely high was instanced by values of from 194 ug/gram in parks in San Diego to 3,357 ug/gram in a downtown Los Angeles Park.[1] Levels of lead in soil around houses painted with lead based paints can also reach values up to 2,500 ppm.[12]

Vegetation

The lead content of plants varies widely depending on location. There does not appear to be any direct relationship between soil lead content and the content of plants grown in that soil. The ph of the soil and many other factors influence the absorption of soil lead by plants. There is, however, a correlation between the lead content of plants grown near highways and distance from the highway, particularly in the leafy parts of the plant.[14]

Motto et al (1970) grew commercial crops to usable maturity at increasing distances from highways. The data in the table following show the tendency for lead from the air to accumulate on above-ground plant structures.

TABLE 2.2.4-1

Lead in Soil and Vegetation Alongside a Major Highway

	49,000 cars per 24-hr.		
Distance from Highway (ft.)	30	100	250
Air Lead (ug/m3)	5.2	3.3	2.5
Soil Lead (ppm) at 0 - 6"	229	130	89
Lead in Carrots (ppm)			
Tops	53	22	17
Roots	9.1	10	5.0

Motto further reported that washing of leaves removed lead from all plants studied. The greatest amount of lead (about 50%) was removed by washing from plants within 75 feet of the road. This indicated that most of the lead in plants near roads arises from airborne lead depositing on the plants.

2.3 Background Levels of Lead in Ontario

The Ontario Ministry of the Environment has conducted numerous investigations into the general levels of lead in the environment in Ontario during the past 5 years. The University of Toronto has also conducted studies in the Toronto area.

2.3.1 Suspended Lead Levels in Urban Communities

Hi-volume filters from selected sites in urban communities have been analysed for heavy metals by atomic absorption spectroscopy. The data for 1971 are shown in Table 2.3.1-1 and can be taken as typical results.[16]

The Provincial median annual geometric mean value is 0.9 ug/m^3 with a range from 0.4 ug/m^3 to 2.4 ug/m^3.

The highest levels are found in the dense urban areas of Hamilton and Toronto with values of 1.7 ug/m^3 and from 1.1-2.4 ug/m^3 respectively. The highest annual geometric mean of 2.4 ug/m^3 was recorded adjacent to the Queen Elizabeth Expressway with a traffic density of 98,000 vehicles/day.

2.3.2 Suspended Lead Levels Near Highways

Studies funded by the Ontario Ministry of the Environment and undertaken by the University of Waterloo[17] have measured the levels and size distribution of particulates and lead near to Highway 401 near the Highway 10 interchange (av. 2365 vph) and by the Queen Elizabeth Way at Evans Avenue.

Data obtained with particle counters confirmed data from the literature that particle concentrations fell off rapidly with distance from the highway.

Particle sizing heads used on high volume samplers at various distances from the highways again confirmed a rapid drop off of both particulate matter and lead concentrations with distance from the highways. Levels were as high as 13 times the background level within 20 ft. of the pavement and reached background levels at distances of about 200 feet from the road. Over 80% of the lead was in the size range below 1.1 μm close to the road with background lead being concentrated in the larger size ranges. The more rapid decrease in lead concentration with distance was in the small size range.

Station	No. of Samples	Fe	Mn	Cr	Ni	Zn	Cu	V	Pb	Cd
		GEOMETRIC MEAN (MICROGRAMS PER CUBIC METRE)								
1. Belleville P.O.	17 to 22	1.2	.04	.014	.026	.1	.09	.02	1.0	.005
2. Bramalea - Fire Hall	11 to 17	1.8	.05	.013	.014	.1	.08	.01	.7	.017
3. Brampton - Old Court House	14 to 24	1.4	.06	.012	.015	.1	.17	.02	1.0	.009
4. Brantford - P.O.	15 to 22	1.2	.07	.008	.023	.1	.05	.02	.8	.004
5. Brockville - Gen.Hosp.	14 to 20	.7	.03	.009	.021	.1	.09	.03	.5	.005
6. Chatham - P.O.	18 to 23	2.0	.06	.012	.070	.1	.07	.04	.6	.002
7. Cornwall - Mem. Park	33 to 49	1.4	.03	.009	.030	.1	.12	.05	.8	.010
Hamilton										
8. (a) Beach - North Park	29 to 38	6.1	.32	.031	.037	.7	.14	.03	1.7	.010
9. (b) North - Barton-Wentworth	58 to 67	6.5	.32	.031	.035	.4	.20	.06	1.7	.009
10. (c) South - Hughson-Main	19 to 24	3.6	.17	.017	.037	.2	.08	.04	1.2	.006
11. Kingston - City Hall	13 to 17	1.1	.03	.015	.025	0	.05	.02	.8	.005
12. London - King-Rectory	14 to 21	1.5	.07	.012	.035	0	.15	.02	.8	.008
13. Malton - Airport	11 to 21	.9	.05	.011	.014	.1	.10	.01	.5	.004
14. Mississauga - Library	13 to 23	2.7	.08	.014	.019	.1	.06	.02	1.3	.008
15. North Bay - Walker's Store	11	.7	.02	.010	.005	0	.05	.02	.5	.004
16. Oshawa - Library	13 to 15	1.2	.08	.017	.030	.2	.07	.01	.9	.007
17. Ottawa - Kenson Bldg.	12 to 19	1.1	.06	.015	.052	0	.07	.13	1.2	.005
18. Peterborough - Fire Hall	11 to 21	1.2	.06	.007	.008	.1	.10	.02	.8	.015
19. Pickering - Fire Hall	14 to 24	.9	.03	.007	.009	.1	.10	.01	1.0	.004
20. St. Catharines - 71 King Street	9 to 16	2.1	.18	.021	.026	.1	.10	.03	1.0	.003
21. Sarnia - Victoria St.	60 to 66	1.8	.04	.011	.018	.1	.17	.01	.9	.007
22. Sault Ste. Marie - Prov. of Ont. Bldg.	22 to 24	1.6	.04	.011	.004	.1	.05	.01	.6	.003
23. [illegible] Hort. Stn.	15 to 20	1.3	.06	.009	.018	.1	.07	.01	.4	.004
24. Sudbury - Ash St.	33 to 35	3.7	.02	.010	.371	0	.50	.01	.5	.008
Toronto										
25. (a) City - 67 College	58 to 69	2.3	.07	.012	.021	.1	.09	.06	1.6	.010
26. (b) E Etobicoke - Evans-Arnold	32 to 42	2.5	.10	.016	.034	.3	.19	.04	2.4	.012
27. (c) North York- Science Centre	19 to 29	.9	.05	.006	.025	.2	.06	.02	1.1	.006
28. (d) Scarborough - Lawrence-Kennedy	24 to 30	1.3	.04	.013	.020	.2	.06	.02	1.5	.014
29. Thunder Bay (N) - 14 Algoma St.	22 to 24	1.9	.04	.004	.004	.1	.08	.01	.8	.002
30. Thunder Bay (S)-Gen.Hosp.	10 to 22	3.5	.05	.006	.002	0	.12	.01	.6	.003
31. Waterloo - P.U. Substation	12 to 17	1.5	.05	.013	.024	.2	.13	.01	1.1	.004
32. Windsor (E) 471 University Ave.	33 to 41	3.8	.13	.026	.048	.3	.10	.05	1.3	.005
33. Windsor (W) - Morton Dock	10	5.0	.15	.022	.021	.1	.10	.01	.9	.014
MEDIAN VALUES		1.5	.06	.012	.020	.1	.09	.02	.9	[illegible]

Table 2.3.2-1 Particle Size Distributions of Suspended Lead Measured in Ontario

Distance from 401	Lead Concn ug/m³ (Hwy 401 1 mile W of Hwy 10 - 2365 vehicles/hr) 7 µm	3.3-7 µm	2-3.3 µm	1.1-2 µm	0.01-1.1 µm	Total
Upwind						
110'	.052	.76	.76	.10	.513	2.185
23'	.46	1.0	.35	.46	6.72	8.99
66'	.28	.30	.23	.30	4.2	5.31
100'	.23	.23	.20	.20	3.5	4.36

Distance from QEW	Lead Concn ug/m³ Q.E.W. at Evans Avenue Exit 7 µm	3.3-7 µm	2-3.3 µm	1.1-2 µm	0.01-1 µm	Total
50'	0.3	0.28	0.18	0.23	2.45	3.44
150'	0	.23	0	0	1.8	2.03
250'	0.16	0.13	0.08	0.53	1.0	1.90
300'	0.10	0.12	0.07	0.07	1.07	1.43

The above studies are continuing in 1974

2.3.3 Lead in Dustfall

Lead in Dustfall has only been determined for the Metropolitan Area with the exception of data from the vicinity of lead processing plants in other parts of the Province. Values ranging from 0.02 to 0.08 tons/mile²/30 days have been found in urban areas remote from industrial lead sources (see section 2.4).

2.3.4 Lead Levels in Soil and Vegetation

Studies conducted by the Ontario Ministry of the Environment have resulted in data on average levels of lead found in soil and vegetation in rural and urban areas and adjacent to major streets and highways.

Table 2.3.4-1 summarizes the data.

TABLE 2.3.4-1

Average Lead Levels Found in Ontario Surveys

SOME AVERAGE LEAD LEVELS	SOIL (ppm, dry wt.) 0 - 2"	VEGETATION (ppm, dry. wt.) not washed	washed
Rural Area	100	15	10
Urban Area	200 - 300	70	35
Adjacent to Highway and Major Street Location	300 - 400	100	50
Considered Excessive	600	150	75

Recent soil studies conducted along Highway 401 indicated a rapid drop-off in soil lead levels with distance from the pavement and a gradation of lead with soil depth such as had been reported in studies in the United States. The data are tabulated below.

TABLE 2.3.4-2 Levels of Lead in Soil Collected in the Vicinity of Highway 401, July 1972

	Levels of Lead (ppm, dry weight)					
	South of Highway			North of Highway		
Distance from pavement (feet)	0-1"	1-4"	8-10"	0-1"	1-4"	8-10"
10	300	88	30	195	83	38
25	183	65	18	103	35	23
50	100	43	15	88	40	18
100	88	33	18	75	35	25
200	58	30	18	55	30	20
500	73	30	18	40	28	18
800	40	23	20	30	20	20

2.4 Background Lead Levels in Toronto

2.4.1 Lead Emission Sources in Toronto

Table 2.4.1-1 gives an indication of sources of lead emissions in the Toronto area. The largest emission in terms of tons/year is from automotive emissions. The lead processing plants are next with municipal incinerators and power plants also contributing significantly. The effect of these sources differs widely and it can be seen that major streets and highways constitute intense local sources with a zone of contamination extending 100 - 300 feet from the pavement depending on traffic density. The effect of emissions from municipal incinerators and power plants is much less, but is more widespread. The lead processing plants lie somewhere between the two with zones of elevated suspended lead occurring up to 3,000 feet from the source.

2.4.2 Measurements of Background Suspended Lead Levels in Toronto

Table 2.4.2-1 tabulates data on suspended lead levels in Toronto. It can be seen that there is a marked gradation from sites remote from highways and streets and the sites adjacent to major roads and highways.

2.4.3 Measurements of Lead in Dustfall in Toronto

In the period January - March, 1973, dustfall samples at locations in Toronto were analyzed for lead. Figure 2.4.3-1 summarizes the results. It can be seen that with the exception of areas near to lead processing plants, values ranged from 0.01 - 0.1 tons/mile^2/30 days (3 - 30 mg/m^2/30 days).

2.4.4 Measurements of Roadside Lead Levels in Toronto

a) Measurements of Suspended Lead Levels at Curbside in Toronto

Data obtained for Environment Canada in 1972 showed curbside lead levels to reach as high as 12 ug/m^3/24 hours. Table 2.4.4-1 summarizes the data.

b) Traffic Related Lead Levels on Bay Street

[illegible] of a program of monitoring [illegible] measured suspended particulate [illegible] particulates at a site 5 metres from [illegible]

TABLE 2.4.1-1

INVENTORY OF LEAD EMISSION SOURCES IN METROPOLITAN TORONTO & AREA

SOURCE	ESTIMATED YEARLY EMISSION (TONS)			ESTIMATED MAX. HOURLY EMISSIONS	
	Env.Can/1970	AMB/1970	Env.Ont/1974	lb/hr. max. Emission	Maximum Calculated 30 Minute Concentration
Canada Metal Company	14.25	30.5	8.0	3.3 (C)	
Rotocast Limited	-	2.2	2.2	4.3 (C)	
Toronto Refiners and Smelters Limited	12.0		10.1 (ST)	3.2 (ST)	
R.L. Hearn Generating Station			0.025 (C)	0.01	
Lakeview Generating Station			0.23	0.06	
Prestolite			7.2 (C)	3.6	
Automotive Traffic	-		1760 (C)	402	
Federated Genco			1.8 (C)	4.0	21
Commissioners St. Incinerator		6.4		1.5	0.5 (30 min.)
Grand Avenue, Mimico		1.3		0.3	0.25 (30 min.)
Symes Road Incinerator		5.4		1.3	0.25 (30 min.)
Ingram Drive Incin.		3.1		0.7	0.15 (30 min.)
Dufferin St. Incin.		3.2		0.7	0.25 (30 min.)
Forest Hill Incin.		0.6		0.2	0.20 (30 min.)
Wellington St. Incin.		3.4		0.8	0.15

INVENTORY OF LEAD EMISSION SOURCES IN METROPOLITAN TORONTO & AREA

(Continued)

SOURCE	ESTIMATED YEARLY EMISSION (TONS)			ESTIMATED MAX. HOURLY EMISSIONS	
	Env.Can/1970	AMB/1970	Env.Ont/1974	lb/hr. max. Emission	Maximum Calculated 30 Minute Concentration
Electric Storage Battery, Scarborough.	-	-	0.6	0.4	
Electric Storage Battery, Mississauga.	-	9.3	2.4 (0.8)	0.7 (.31)	
Tonolli, Mississauga	6.10	5.65	5.6	1.5	15
Globelite Batteries	-		0.3	0.4	11
Ingot Metal Company	-	-	9.6	-	
Anaconda Brass	-			0.2	
Dominion Colour	-		6.4	1.6	
London Stamp & Stencil			0.016	-	
Metals & Alloys			0.3	-	
Neptune Meters			0.25	-	
Signode Canada			0.27	-	
Toronto Star			0.7	-	
Globe & Mail			0.6	-	
TOTALS					

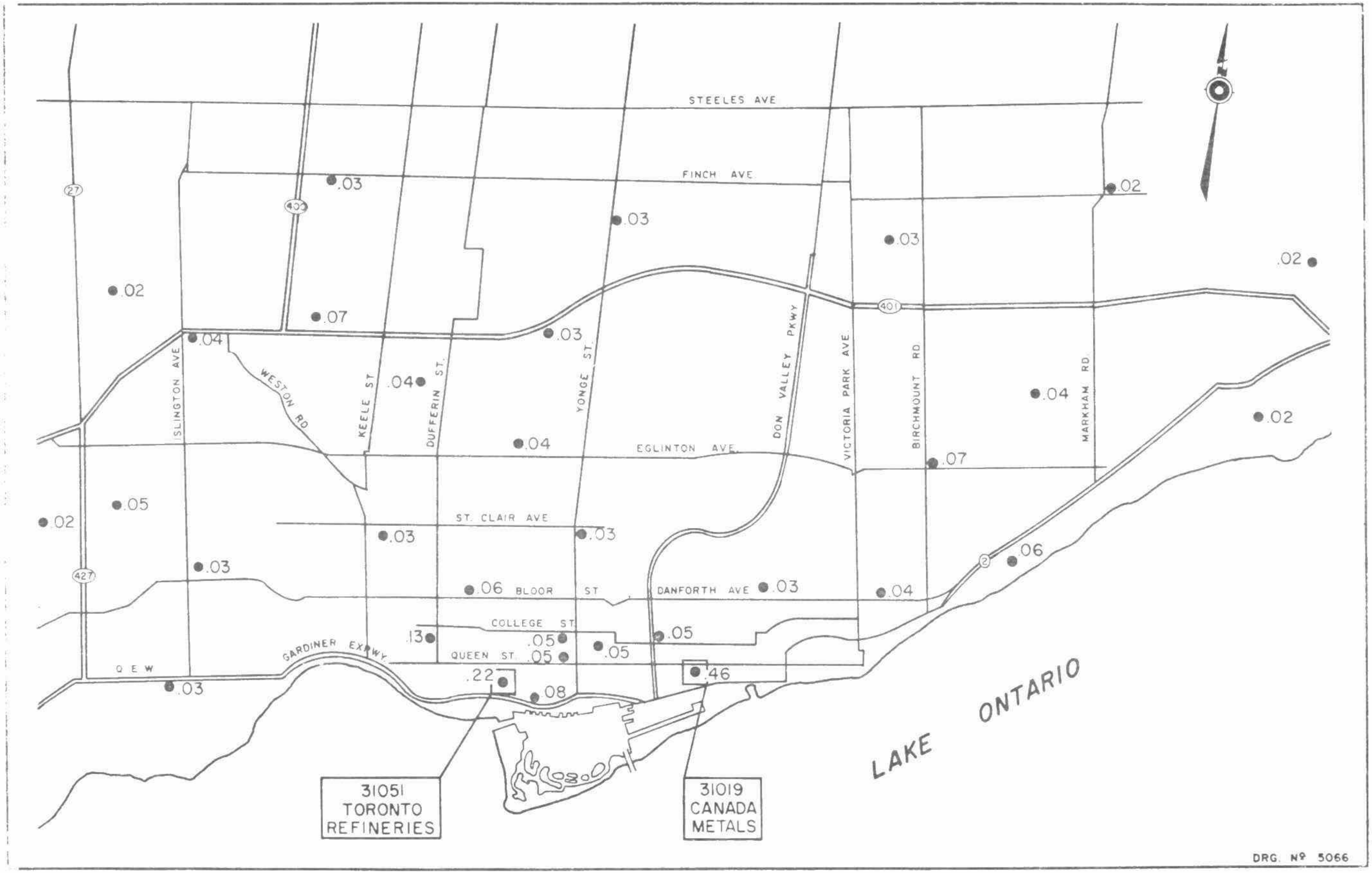

FIGURE 2. 4. 3-1 - AVERAGE MONTHLY LEAD IN DUSTFALL
JAN., FEB., MAR. 1973, (TONS/SQ. MILE/ 30 DAYS)

TABLE 2.4.2-1 DISTRIBUTION OF SUSPENDED LEAD LEVELS IN TORONTO

STATION NO.	LOCATION	FEET TO HWY. OR MAJOR ST.	FEET TO ARTERIAL ST.	VEHICLES PER DAY	LEAD LEVELS ug/m^3		REMARKS	HEIGHT OF HI-VOL ABOVE GROUND
					MAX.	ARITH MEAN		
33019	Scarborough Bluffs	2,800 ft. to Kingston Rd.	830 ft. to Brimley South	28,300	1.9	0.7	1972 Data	3 feet
35033	Evans Avenue, Q.E.W.	330 ft. to Q.E.W.	200 ft. to Evans Ave.	95,000	7.5	2.5	1972 Data	3 feet
35006	47 Allonsius Dr., Etobicoke	5,000 ft. to Hwy. 27	150 ft. to Allonsius Dr. 500 ft. to Renforth	(4,900)*	3.2	1.2	1969 Data	3 feet
35003	Elmcrest Road, Etobicoke	9,000 ft. to Hwy. 27	310 ft. to Elmcrest Rd.	(1,000)	2.7	0.8	1972 Data	12 feet
34007	Bathurst & Wilson Dept. of Highways	105 ft. to Hwy. 401	500 ft. to Wilson	150,000	10.5	4.2	1971 Data	3 feet
34002	Science Centre, Don Mills	2,000 ft. to Don Mills Rd.	3,000 ft. to Eglinton	25,700	5.4	1.5	1971 Data	30 feet
33003	Lawrence and Kennedy Scarborough	2½ miles to Hwy. 401	67 ft. to Kennedy, 550 ft. to Lawrence	(17,200)	3.7	1.7	1971 Data	3 feet
33002	Pharmacy & 401	54 ft. to Hwy. 401	88 ft. to Pharmacy	85,200	8.5	4.0		3 feet
33001	Crocus Drive, Scarborough	100 ft. to Hwy 401	1,000 ft. to Warden	75,700	4.9	1.5	1969 Data	3 feet
31026	360 Christie St.	500 ft. to Christie	130 ft. to Melita Ave.	11,000	1.8	1.2	1971 Data	20 feet
31001	67 College St.	130 ft. to College St.	40 ft. to Elizabeth	21,000	[illegible]	1.3	1972 Data	65 feet

* Figures in brackets denote traffic density on nearest arterial street

Carbon monoxide levels were also measured simultaneously and 3 hour averages computed. Traffic counters were installed on both North and Southbound lanes.

Airborne lead values ranged from 1 to 4 ug/m^3/24 hour average with a median value of 1.8 ug/m^3 and displayed a log-normal distribution. There was a good correlation between traffic density and lead levels on weekdays (10 days sampled) but the correlation was poor for weekends (3 days sampled). There was also a very strong correlation between CO and lead levels confirming the findings of previous studies.

The average value of 1.8 ug/m^3/24 hours at 5 metres from a road with 22,000 vehicles/day is of the same order as the data of Rutgers University (2.12 ug/m^3 with 19,750 vehicles/day) and is much lower than the curbside values of Environment Canada. It would, therefore, appear that there is a rapid dropoff in suspended lead levels with distance from urban streets with moderate traffic densities. It is unlikely that elevation of lead levels above background is significant beyond 15 - 30 feet from the roadway.

TABLE 2.4.4-1 Environment Canada Data on Suspended Lead Levels at Curbside in Toronto

Site Location	8-Hour Traffic Volume	Approx.* Max. 3 Hour Lead Conc.ug/m^3	24 Hour Lead Concentration ug/m^3		
			Max.	Min.	Aver.
Bloor & University	34,802	13.5	12.0	4.0	8.2
Spadina & Bloor	20,140	17	12.1	7.5	9.4
University & Adelaide	26,745	6.5	6.2	2.6	4.2
Wellesley & Bay	22,141	8.5	7.9	2.5	6.1
Adelaide & Jarvis	18,181	10.5	8.6	2.0	5.8
King & Bay	14,455	5.0	2.2	4.8	3.0

*Read [illegible]

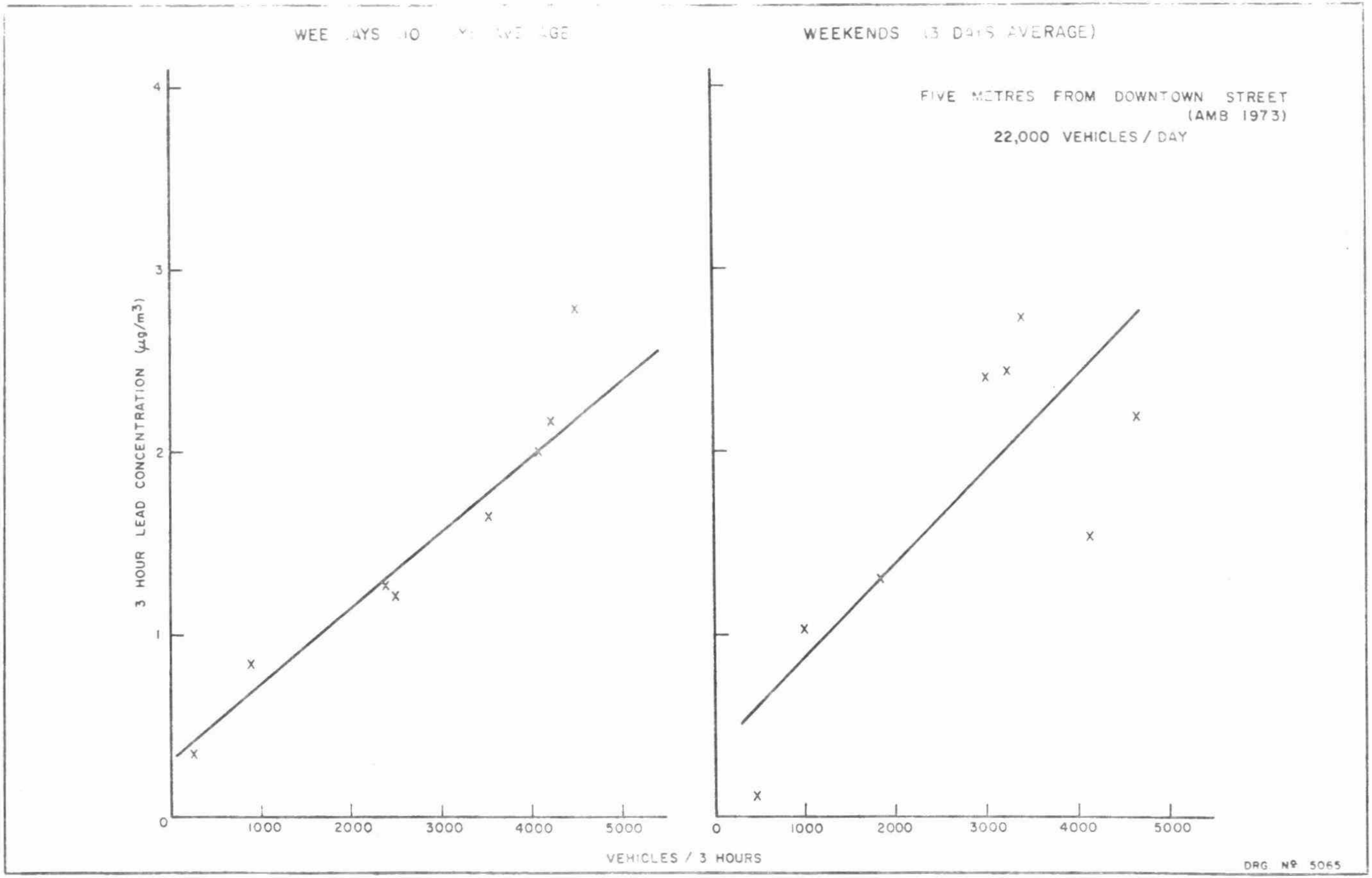

FIGURE 2.4.4-1 - CORRELATION OF TRAFFIC VOLUME AND LEAD - BAY ST.

2.4.5 Lead Levels in Vegetation and Soil in Metropolitan Toronto

A phytotoxicology survey was conducted by the Ontario Ministry of the Environment in 1971 in Metropolitan Toronto. Vegetation and soil samples were collected at 65 major intersections throughout Metro. Vegetation samples were collected from representative trees, shrubs, weeds and grass at each location and soil was collected at both 25 and 75 feet from the intersection. The following figures show the chemical analysis results for lead contents in the sampled vegetation and soil. Figure 2.4.5-1 shows the average lead contents in not washed vegetation for Metro in four zones of contamination levels (0-50, 50-100, 100-150, and over 150 ppm). Generally, rural to suburban residential areas fall in the 0-50 ppm lead zone; urban residential, commercial and major roads fall into the 50-100 ppm lead zone; industrial fringe areas and the downtown core fall into the 100-150 ppm lead zone; and industrial lead sources and the intersection of major highways fall into the over 150 ppm lead zone.

Figure 2.4.5-2 shows the average lead contents in surface soil for Metro in four zones of contamination levels (0-100, 100-600, 600-1000, and over 1000 ppm).

2.5 Discussion of Expected Lead Levels in Toronto

On the basis of the data presented on background levels in urban areas and lead levels adjacent to highways and main arterial streets, it is possible to predict the expected lead levels in various parts of the city. It would be expected that the lowest levels would occur in suburban residential areas remote from traffic and industrial sources and the highest levels in downtown areas near highways and industrial sources.

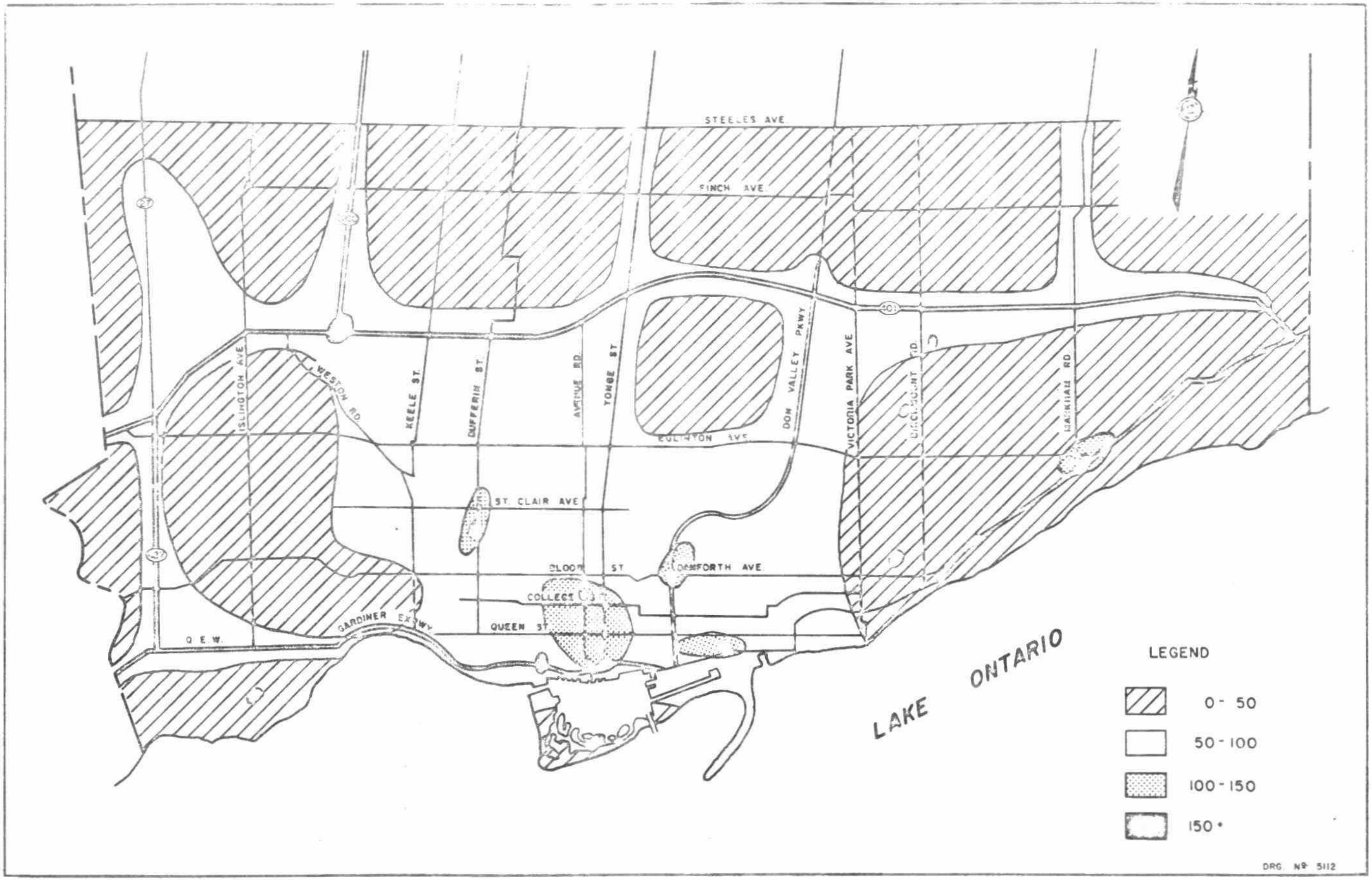

FIGURE 2. 4. 5-1 - AVERAGE LEAD LEVELS IN NOT WASHED VEGETATION (PPM)

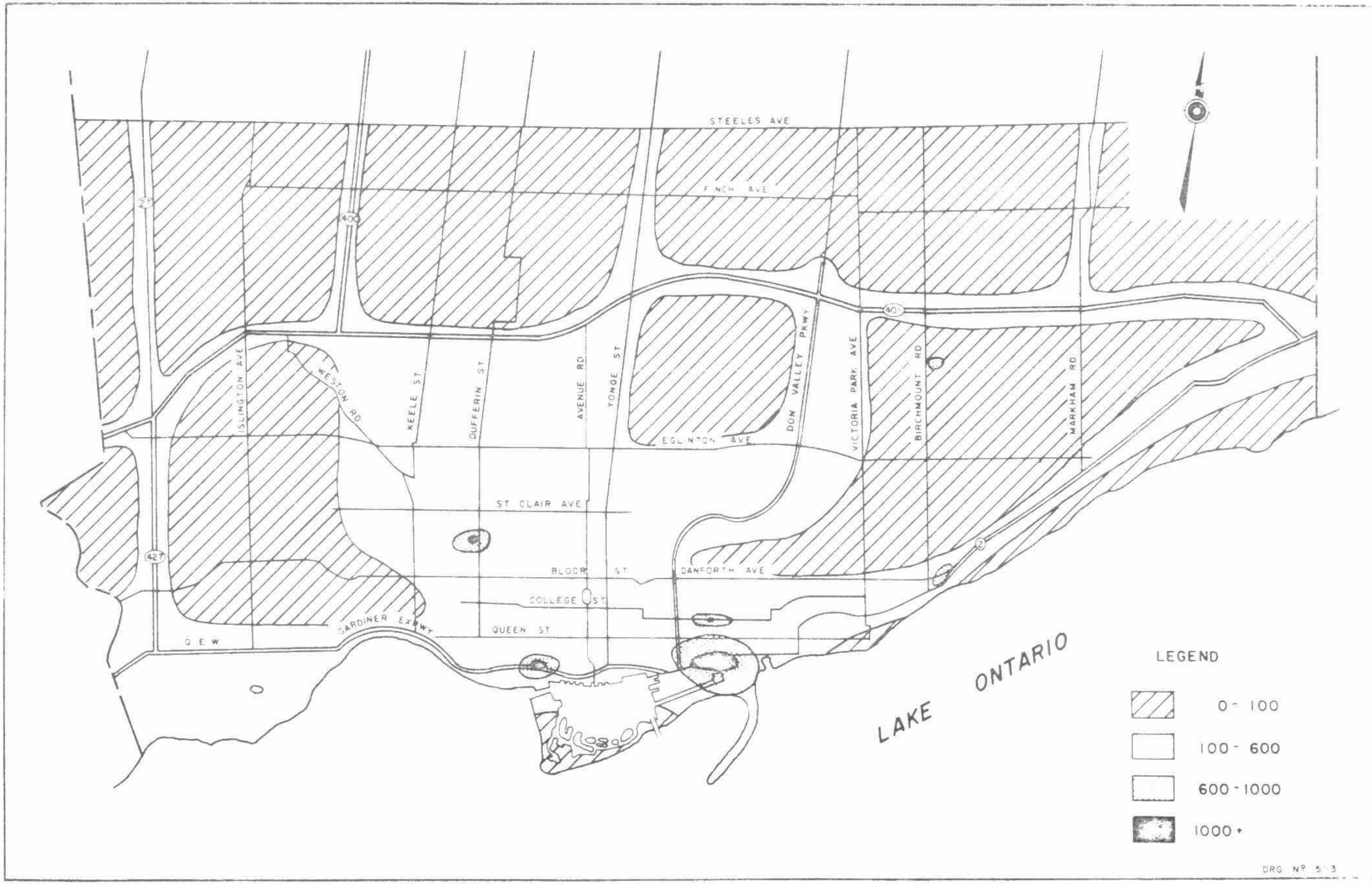

FIGURE 2.4.5-2 - AVERAGE LEAD LEVELS IN SURFACE (0" - 2") SOIL (PPM)

Table 2.5-1 classifies the types of areas that would be found and gives the expected range of environmental lead levels in each area.

TABLE 2.5-1 Classification of Toronto According to Expected Lead Levels in the Environment

TYPE OF AREA	EXPECTED LEAD LEVELS			
	AIR ug/m3/24 hrs.	DUSTFALL tons/mile2/30 days	SOIL ppm.	VEGETATION ppm. (not washed)
1. Suburban remote from traffic & industry.	0.5 - 1.0	0.01 - 0.05	20 - 200	1-50
2. Downtown away from traffic and industry.	1.0 - 2.5	0.03 - 0.08	100 - 400	50-100
3. Downtown 200-500 feet from expressway (remote from industry).	2.0 - 10.0	0.05 - 0.15	200 - 600	100-150
4. Downtown 10-50 feet from major arterial street (remote from industry).	1.5 - 5.0	0.05 - 0.15	200 - 600	100-150

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3. LEAD AND HUMAN HEALTH

3.1 Lead in Man's Environment (Natural Sources)

3.1.1 Lead in Soil

While lead in sufficient concentration (3 - 8%) and in accessible areas to warrant mining is comparatively rare, almost all rocks and soils contain some lead. While the average concentration is about 15 parts per million (ppm) in soil, there is considerable variation with few soils being found with levels of lead too low to detect.

3.1.2 Lead in Plants

The widespread occurrence of low levels of lead in soils means that plants grown in them are exposed to and take up lead. The amount of lead absorbed by the roots of the plant depends both on the type of soil, the type of plant and the season of the year.

3.1.3 Lead in Water

While there is no direct way of measuring the lead level of surface waters prior to the Industrial Revolution, some judgments based on measurements of lead levels in water made in recent years can be made.

The generally low concentrations of lead presently found in rivers and lakes away from obvious sources of lead contamination (between 1 - 10 micrograms

per litre suggest that the levels in the past would have been even lower.

In the sea, because of the very slow mixing of the deep layers of the ocean with surface waters, measurements of the lead content of water from below 2000 metres probably approach the lead levels existing generally in sea water prior to industrial activity. The lead levels in such sea water samples range from 0.02 to 0.04 microgram per kilogram .

The lead levels in precipitation several thousand years ago can be measured directly under special circumstances since the snow falling in such places as northern Greenland is compacted into ice sheets which form chronologic layers. The lead levels in snow deposited around 800 B.C. in northern Greenland are less than 0.0005 microgram per kilogram .

In general it may be concluded that the lead levels in water before 1700 A.D. were extremely low.

3.1.4 Lead in Air

There is no direct method of measuring the levels of lead in air thousands of years ago but in measuring lead in precipitation, particles and gases are trapped by the snow or rain in the atmosphere and carried to the surface of the earth. Thus it can be assumed that, if very low concentrations of lead are found in frozen precipitation, the levels of lead in the atmosphere at the time the precipitation occurred were also very low. These very small amounts of "natural" lead in the atmosphere result from windborne dust and from the decay of Radon gas which diffuses from the earth's crust.

Theoretical Estimates of Natural Levels of Lead in Air, Water and Soil

Dr. Clair Patterson has estimated from theoretical considerations the levels of lead that would have existed in the air, water and soil prior to man's discovery of lead and while such calculations must be highly speculative, they suggest that the level of lead in the air was very much lower than today in all but very remote areas. Patterson estimates the atmospheric lead level due to purely natural causes without man's intervention as in the range of 0.0005 - 0.0006 microgram per cubic metre while measured atmospheric lead levels from northern Greenland show a level of 0.005 microgram per cubic metre. Similar measured levels have been found in Siberia and at high elevations in the White and Laguna Mountains .

3.1.5 Lead in Animals, Including Man

As in soils, plants contain low concentrations of lead and they, in turn, contribute lead to the diet of animals either directly in the case of animals which eat plants or indirectly in the case of animals that eat flesh. Man being omnivorous may be presumed to have always absorbed some lead from both plants and animals in his diet. This speculation is borne out by analyses of ancient human bones such as those of 40 Indians living in Arizona during the period 700 to 1450 A.D. These specimens were from original burial sites and did not include museum material. The lead levels in the bone ash of the ribs were 6 to 8 ppm while that in native skulls from Mexico from the time of the Conquistadors, circa 1520, had a range of 2 to 4 ppm lead in the ash . Similar results were found for bones from the third century A.D. discovered in Poland, the lead levels ranging from 1.81 to 3.40 ppm .

Man's Effect on the Natural Lead Levels in his Environment

Lead has been used by man since at least 1500 B.C. when there is mention of leaden objects being captured by the armies of Pharoah Thutmosis III. The scale of use of lead in the ancient world, however, was not such as to alter the lead concentration of man's environment as a whole, although by the second century B.C. there is written evidence that workers with lead were known to have developed the abdominal colic and muscular paralysis that have become classic signs of lead poisoning in adults.

From this time until the beginning of the Industrial Revolution man contaminated only his local environment with lead by intentional or accidental adulteration of cider , rum , food or drinking water conveyed in lead pipes .

With the coming of steam power and the ability of man to enlarge the size of his smelters and factories more extensive contamination of the environment with lead began. This increase in contamination can be deduced from several pieces of evidence. In the studies previously referred to of the levels of lead in the ice in Greenland it was found by Murozumi that the lead levels in the ice formed by snow falling during the early years of the Industrial Revolution are 25 times those found in 800 B.C., while today the lead concentrations of recently fallen snow are about 400 times the pre-industrial levels. Similar information has been derived from studying the lead levels in two Polish glaciers which show that lead levels have risen by a factor of ten in the past century .

It is of interest that the lead levels in Antarctic ice sheets do not show similar increases to those found in the Arctic. This is probably due to the generally

lower level of industrialization in the Southern Hemisphere and the relatively poor mixing of air between the two hemispheres.

Further evidence of increase in lead contamination is provided by a comparison of the lead levels in mosses gathered during the years 1860 to 1968. Over this period the lead levels in the mosses rose four-fold with the sharpest rise occurring after the end of the Second World War . This latter finding is paralleled by a similar sharp increase in the lead levels in the Greenland ice after 1940.

In comparing the levels of lead in bone found in the studies already mentioned with those found today an increase of between 10 and 20 times is found . Such a general statement needs qualification, however, for Jaworowski's data show that the lead levels in bone were higher in the 19th century than they are today, while a study of lead levels in hair has also shown a fall from a mean of 164 ppm for children's hair from the period 1871 - 1923 to 16 ppm in hair from present-day children. The change in the lead concentration in adults' hair was from 93 to 6.5 ppm . These results suggest that the total amount of lead absorbed from all sources was greater at the turn of the century than it is today despite an undoubted increase in the lead levels of the air in urban communities. Such a finding would be in keeping with what is known of the opportunities of lead to enter the diet in the period between 1700 and 1900 at which time improved food technology and higher standards of sanitation began to reduce the lead taken in with food and drink.

3.2 Present Levels of Lead in Man's Environment

The mere presence of lead in man's environment does not, by itself, necessarily threaten his health, e.g., the lead sinkers on an angler's fishing line. It is the concentration and the form of the lead in relationship to man's activity that may endanger health. For instance, adults can, and do live in dilapidated housing with lead paint peeling from the walls without suffering from lead poisoning but a child just able to walk and who explores this same housing using his hands and mouth may be in grave danger of lead poisoning through ingestion of the flakes of lead paint.

A knowledge of present lead levels in the environment can help in locating those areas where the risk of lead absorption by humans is greatest.

3.2.1 Lead in Soil

It has been calculated that despite the general world-wide dissemination of lead due to man's activity, the average increase in soil lead level due to lead in precipitation (approx. one microgram per square centimetre per year) and dustfall (0.2 microgram per square centimetre per year) is probably too small to measure (0.04 - 4 micrograms of lead per square centimetre per year) . To date, attempts to measure the global effects of lead pollution by measuring changes in the lead levels in soil have been unsuccessful and have borne out the theoretical prediction .

In contrast to this difficulty in recognizing a world-wide increase in soil lead levels, local increases due to local sources have frequently been detected and measured.

In the vicinity of lead mines the "spoil" may increase the lead level in the surface soil so that plants grown in them are enriched in lead and represent a hazard to animals grazing on them . In mining areas the transportation of lead concentrates from the mines to the smelters in open trucks has resulted in a ten-fold increase in soil lead levels alongside the highway used by the trucks carrying lead ore compared with roads not travelled by such trucks. While this study does not state whether the traffic densities were similar on the two sets of highways it is important because it points to a possible problem posed by the conveyance of all toxic, dusty materials in uncovered trucks and railroad cars. Battery scrap going to secondary lead smelters would be such a material.

In recent years a great deal of data have been accumulated showing that the burning of gasoline containing lead antiknocks is the most general source of environmental lead contamination. This matter and current lead levels in air and water have been discussed in greater detail in Section 2.0 of the report.

3.2.2 Lead in the Diet

The air he breathes and the food he eats represent man's most intimate contacts with the lead in his environment.

For a few persons with specialized occupational exposure such as those engaged in the manufacture and blending of lead antiknock agents together with those men who remove the sludge from gasoline storage tanks, the skin may also represent a surface through which lead can enter but this is a hazard peculiar to these occupations.

For the reasons stated earlier there has always been lead in man's diet and there is some evidence that the amount of lead increased with the beginning of the Industrial Revolution. This increase was unlikely to have been due to general lead contamination of crop and grazing land but was more likely due to the use of lead arsenate insecticides and lead in food processing equipment. With the introduction of organochlorine and other non-lead-containing insecticides, together with the introduction of stainless steel in food processing equipment, lead levels in the diet appear to have dropped. Other sources contributing lead to the food in earlier years were the use of pewter eating utensils and of glazed earthenware with a high lead content. Both of these sources have largely disappeared although improperly fired lead glazed pottery still accounts for a few cases of lead poisoning each year.

The lead levels in the diet do not seem to have changed much during the past forty years and this belief is supported by the observation that the blood lead levels of populations studied during the past thirty years do not seem to have changed significantly. Of course the blood lead level reflects lead absorption from all sources - not only the diet - and so it is possible that lead levels in the diet have continued to drop but this effect has been balanced by an increased contribution of lead from the air. The amount of lead in a person's diet will vary considerably from day to day and to some extent with food preferences but two reasons tend to make generalizations about the dietary intake of lead of some value. The first is that no normal items of the diet differ very greatly one from another in their lead content with the exception of some molluscs such as oysters and the second reason is that, in North America, the diet of most people is made up of items from a very wide variety of sources so that local influences on lead content tend to be of little importance over a period of time.

A number of recent studies have shown that the average content of the diet in North America is between about 106 and 220 micrograms of lead per day for adults . Studies in children have been few but there has been reasonable agreement on the levels of lead both between authors as well as estimated and measured results. The conclusions of these studies suggest that the dietary lead intake of children should be related to their weight, or more correctly, their surface area. A child two years old, for instance, eats a diet containing about half the number of calories of an adult and may, therefore, be assumed to take in about half as much lead. This would result in a lead intake for a two-year-old child of between 53 and 110 micrograms of lead per day. Support for this being a realistic range for the lead intake of a two-year-old child is supplied by the studies in England of actual dietary lead intakes in children and of the estimated intake of a child of this age . This latter investigator suggests 75 micrograms per day as the average lead intake for such a child. Because of the difficulty of measuring the lead levels in the diet actually eaten by young children, it has been more usual to measure the average daily lead content of the feces which represents about 90 percent of the intake of the element. Studies in which this has been done suggest that the daily intake in children in the United Kingdom and North America is about 10 micrograms of lead per kilogram of body weight in the age range of 0 to 5 years.

In considering the diet of young children it is of interest that in 1968 the lead level of some U.S. evaporated milk was found to be as much as 0.8 ppm. A program jointly instituted between the industry and the U.S. Food and Drug Administration has resulted in a reduction in lead level until the average lead content of over 3000 samples of evaporated milk taken during the first six months of 1973 was 0.12 ppm .

3.2.3 Other Potential Sources of Lead Intake in Man

Apart from the lead which is either inhaled or eaten under "normal" urban circumstances some human activities or unusual conditions may increase the lead intake still further. These may be:

(1) Pica

Pica is defined as the eating of non-food items and is a common activity in young children. When this involves paint with a high lead content, considerable intakes of lead may result from the ingestion of flakes only a few millimetres in diameter. Children may also eat garden soil and almost inevitably all children ingest some house dust. If the soil and/or the house dust contain high concentrations of lead they may provide a significant source of lead absorption.

The eating of lead paint by young children has been the single most important cause of lead poisoning in children in the United States. Such poisoning is seen almost exclusively in children of pre-school age who live in deteriorated housing built before 1940. Since that time titanium dioxide pigments began to replace the pigments in most interior paints.

The repeated ingestion of leaded paint chips for about three months or longer can lead to clinical symptoms and eventually to the absorption of a potentially lethal body burden of lead. Three factors appear to be important in the causation of this type of lead poisoning; a poorly kept, older house, a young child with pica and parents with inadequate

resources (emotional, intellectual, informational and/or economic) to cope with the family's needs .

In Canada, for reasons that are not understood, the tragic experience of the United States with childhood lead poisoning does not appear to have been repeated and it would not have been missed if it had occurred on the same scale as in Baltimore, Philadelphia and New York. It is, however, possible that a lesser problem might have been missed since the early signs of lead poisoning are non-specific and physicians not alert to the possibility might not make the diagnosis.

Blood lead screening programs such as those conducted in New York and Chicago have not been carried out in Canada prior to those reported in this report and so the percentage of children having high blood lead levels has been unknown. It can be concluded that if Canada has a childhood lead poisoning problem it must be small compared with certain cities in the U.S. and that the reasons for this remain speculative at this time but probably include social, economic and, perhaps, climatic factors.

(2) Soil, Street and House Dust

As with pica for paint, for soil, street and house dust to be significant sources of lead intake it is necessary not only for the lead content of the soil and dust to be high but also human behaviour must be such that these materials are eaten. This eating may be deliberate, as with paint, or it may be inadvertent as with house dust or street dirt. The hazard posed by the lead in soil and dust is disputed; some investigators feel

that it has not been demonstrated to be an important hazard while others have pointed to the concentrations of lead that have been found in urban dust and soil as certainly representing an opportunity for amounts of lead greater than those normally eaten in the diet to be ingested during the course of normal childhood behaviour .

(3) Chewing on Comics and Newspapers

Several investigators have found that pigments used in the printing of the coloured pages of some magazines and comics contain high levels of lead . One case of high blood lead level in a child in the U.S. has been reported as possibly due to the chewing of newspapers and magazines, a type of behaviour which had been observed. In some English and U.S. comics levels of several thousand ppm lead have been reported for a single page and such an amount eaten from time to time could cause lead poisoning since a single page would exceed the acceptable level of lead in the diet by as much as a ten-fold factor. Studies still in progress by the Ontario Ministry of Health have not shown Canadian comics and coloured supplements to contain high lead levels.

(4) Occupational

In any consideration of environmental lead levels and human lead intake the working environment must be considered as both historically and currently an important potential source of lead absorption. The relevance to the present community studies in the Toronto area is clear because workers in the lead industries may also be residents of communities close to the plants where they work and any lead absorbed during the course of employment will be added to by any additional absorption in the community.

Poor personal hygiene may be a very significant lead exposure to some employees. In addition, employees that are allowed to go home in their contaminated working clothes or employees failing to wash thoroughly before leaving the plant may result in lead dust being carried home to contaminate the home. Such cases have been strongly suspected in the investigation of community lead contamination in other countries.

(5) Drinking Water

Lead in drinking water has traditionally been a problem associated with soft water and lead water supply pipes; such associations are thought to be rare in Toronto but studies are currently under way analyzing water from the homes of persons found to have high lead levels as well as visual inspection for lead piping by the Public Health inspectors. That even today new sources of water contamination can be found is illustrated by the finding of levels of up to 8 ppm lead in water boiled in some models of electric kettles. This discovery by the Department of Health of the City of Toronto has resulted in action to eliminate the use of lead solder in those portions of the kettle coming into contact with the water.

(6) Unusual Dietary Sources

The most common dietary source of lead poisoning in the southern U.S. is illicitly distilled liquor. The lead contamination may occur in several ways but one of the most important is the use of old automobile radiators as a condenser with consequent leaching of the lead from the soldered joints. About half of the samples of illicitly distilled liquor tested have had concentrations of lead greater than 1000 micrograms per litre. In Canada illicitly distilled liquor which has been impounded is routinely tested for lead content and it is seldom found to be elevated.

Lead may also enter the diet from improperly glazed ceramic containers and, while this has already been referred to as a problem in commercial potteries, it is potentially even more of a problem for the home hobbyist who does not use lead-free glazes and where the ceramics may not be fired at a sufficiently high temperature. If acidic drinks such as cola or cider are held in containers made under these conditions they may leach out the lead and hazardous concentrations can be produced in the beverage.

3.3 Health Effects of Lead

3.3.1 Uptake

As has been previously mentioned, lead may be taken into the body by inhalation, ingestion or through the skin. Only inhalation and ingestion will be dealt with here since skin absorption is only met with under certain specialized circumstances in industry.

Uptake From the Lungs

Although lead may be present in the environment as a suspended particle in the air, this fact alone does not guarantee that it can be inhaled and absorbed by man. The size of the particles of lead dust will determine the fraction which is deposited in the lung. Particles larger than 7 microns in diameter are generally filtered out by the nose and large air passages high up in the respiratory system. These large particles are usually removed by sneezing or coughing where a certain percentage will gain access to the throat and be swallowed. Particles below the size which are caught by the upper airways may descend down into the lung but here again their size determines their fate. About 60% of the particles having a diameter of between 2 and 3 microns are retained within the lung and as the particles become smaller this percentage drops until with a particle size diameter of 0.5 micron, only about 25% of the particles will be retained in the lung, the rest being exhaled. With still smaller particles the percentage retained in the lung again rises towards 60%.

Not all particles that have survived the body's filtration mechanisms and have been deposited in the lung will stay there. A proportion of them will be taken up by scavenging the cells within the lung and some of these cells will carry the contained lead particles upwards to be coughed up and perhaps swallowed. Others of the necrophaged cells will penetrate the walls of the lung and can then be considered within the body although they may remain within lymph nodes in the area for some considerable period of time. Particles deposited on the walls of the larger air passages can be moved upwards by the action of fine hair-like processes called cilia and these can raise the particles to the back of the throat where they may be swallowed.

A fine lead particle lying in the deep spaces of the lung will gradually be dissolved and absorbed into the bloodstream. The rate at which this occurs will depend upon the size of the particle and its solubility.

There is still a considerable amount of discussion as to the percentage of the lead in the urban air which is retained and absorbed. This uncertainty arises from the extreme difficulty of carrying out experiments which accurately reproduce real life conditions. At the present time the figures most often used for combined retention and absorption is 37% of the lead typically found in an urban environment. Two of the most careful workers in the field, however, have reported the proportion of lead particles retained in the lung to be as low as 10% while other workers using slightly different techniques have found the percentage of lead retained to vary from 27 to 62%. The question of the retention of lead particles in the lung has been discussed at some length because this percentage retention is critical in using any mathematical model and variations in the retention factor will cause quite large differences in the amount of lead assumed to enter the body.

3.3.2 Gastrointestinal Absorption

In adults it is probable that under normal conditions not more than five to ten percent of the lead ingested in the diet is absorbed from the gut. The situation in children is far less clear partly because of the understandable lack of experiments in this area. In studies measuring the input and output of lead in children , it was shown that there was approximately 50% retention from the gut but whether this represents a true difference in the behaviour of the lining of the gut or rather indicates that the growing child who maintains relatively

constant tissue levels of lead must, of necessity, retain a higher percentage of the lead in the diet than an adult, is not known. Some suggestion that the lining of the gut in young animals handles lead differently from that of mature animals is provided by a recent study of lead uptake in rats in which 50% of the lead of the diet of very young rats was absorbed.

3.3.3 Uptake by the Blood

The lead which is retained and dissolved in the tissue fluids of the lung and intestinal mucosa is picked up by the blood where 95% of it is bound to the red cells.

Lead is transferred from the blood to the other body tissues and if the intake of lead by the body is constant, the blood and soft tissues such as liver, kidney and muscles will come into a state of dynamic equilibrium with the lead in the blood.

Lead, like strontium, is a bone-seeking mineral and under conditions of long continued, steady intake about 90% or more of the total body lead is stored in the skeleton. Because the lead takes part in the formation of the crystalline structure of the bone in which form the lead can generally be considered inert and has no effect upon the body. If, however, the body rate of lead intake decreases it will be removed from the bone at a very slow and constant rate. There have been suggestions in the older literature that under certain circumstances lead may be released more rapidly from the bone. Factors which have been incriminated have been acute or chronic infections, fever, fractures and excessive alcohol intake. Although, in general, objective evidence to support

these claims is lacking, it is reasonable to suppose that if lead and calcium are metabolized similarly in bone, then factors which tend to release one will also release the other.

3.3.4 Excretion of Lead

Although it is commonly said that lead is a cumulative poison, this means no more than that lead is fairly slowly excreted from the body and it is comparatively easy to take in lead faster than the body can excrete it through the kidneys and bile.

For practical purposes, most human beings can be considered in lead balance where the amount of lead taken in from all sources is balanced by the excretion in the urine and feces. It is known that this is not absolutely true since there is a slow but steady increase in the lead content of the skeleton throughout life but for the reasons previously given this lead is not considered to affect health.

3.3.5 Effect of Lead on Blood Formation

It has been known since man first began to work with lead that one sign of lead intoxication was that people became pale. In recent years the reason for this pallor due to lead has become clear and it is now known that it is due to an interference with the formation of hemoglobin, the red pigment of the blood. This interference by lead is caused through its effect on an enzyme ALA or aminolaevulinic acid dehydrase. It has been shown that there is a direct relationship between the concentration of lead in the blood and the activity of

the enzyme. It has also been found that there is no amount of lead so small that it does not, to some extent, decrease the activity of the enzyme. While this is known to happen in the test tube, it seems unlikely that this can happen exactly in this fashion in the body since it would be expected that any decrease in the enzyme's activity would be demonstrated by some interference with the body's building of the hemoglobin molecule. This would most likely be shown by the buildup of the raw material, aminolaevulinic acid, which through the activities of ALA dehydrase are brought together to form porphobilinogen, but such a buildup of aminolaevulinic acid does not occur at blood lead levels below 30 micrograms of lead per hundred millilitres of whole blood and is not appreciable until the blood lead level has risen to around 40 micrograms of lead per hundred millilitres of whole blood. This apparent inconsistency between the effect of lead on the activity of an enzyme in the test tube and the effect in the body might be explained by assuming that the body has a large excess supply of the enzyme. This finding would be consistent with the finding that lead workers in very high exposures may have no demonstrable ALA dehydrase activity but yet not be anemic and appeared to be in good health. It has also been found that dogs with no measurable ALA dehydrase activity due to a high lead diet can after being bled manufacture hemoglobin just as fast as dogs that have been on a normal diet that have been bled by a similar amount. Almost all of the information we have on the effect of lead on the synthesis of the heme portion of the hemoglobin molecule comes from observations on red blood cells. Yet all the cells of the body synthesize their own heme containing enzymes and ALA dehydrase is widely distributed in all tissues. This would suggest that the observations on red blood cells may serve as a model of lead's probable effects on heme synthesis in other organs. This has been shown to occur in the brain tissue of laboratory rats fed levels of lead that produced

levels of about 30 micrograms of lead per hundred millilitres of blood the level of ALA dehydrase activity in the brain did not differ significantly from the levels found in rats that had not been given any added lead at all.

So far it is only in the blood that it is possible to measure a direct cause-and-effect relationship between the biochemical disturbance in the body and its effects on health in animals or people. In the blood this effect on health is anemia brought about by a decrease in heme synthesis. This decrease leads, in turn, to a diminished life-span of the red cells and later to a decrease in their number and in the amount of hemoglobin in each cell. To compensate for these effects, the blood forming tissues step up their production of red cells and, as a result, immature red cells appear in the circulation. Despite the fact that an interference of heme synthesis can be found at blood lead levels of around 40 micrograms of lead per hundred ml of whole blood, anemia is not normally seen until much higher blood lead levels are reached and in adults these levels have been found to be in excess of 100 micrograms per hundred ml . Despite this lag between the early biochemical detection of the effect of lead and the clinical expression of this biochemical disturbance, it is important to recognize that arithmetic increases in the lead content in blood above 40 micrograms per hundred ml of whole blood are associated with exponential increases in urinary aminolaevulinic acid output and with other measures of the metabolic effects of lead and of the amount of lead stored in the bone. For the clinician this curvilinear relationship between the blood lead content and measures of the biochemical effects of lead indicates that arithmetic increases in blood lead concentration are associated with an exponentially decreasing margin of safety. For example, an increase in blood lead content from 40 to 60 micrograms per hundred millilitres of whole blood may be associated with relatively little change in health status whereas an increase from 60 to 80

micrograms per hundred ml of whole blood markedly increases the risk of symptomatic illness. The diagnostic evaluation of human subjects may be based on the concept of exponentially increasing risk that attends arithmetic increases in blood lead content.

3.3.6 The Effect of Lead on the Nervous System

The effect of lead on the nervous system has been one of the earliest observations of man since he began working with lead. Both the peripheral and central nervous systems may be affected and the degree to which these two systems are affected is responsible in large part for the difference in the clinical picture between adults and children suffering from lead poisoning.

In adults in whom effects on the peripheral nervous system are more pronounced and form a prominent part of the clinical picture of lead poisoning weakness of muscles, particularly those most often used, may be the first evidence of poisoning. This weakness of the muscles appears to be at least partly due to damage to the nerves supplying the muscles and appears to be largely reversible when exposure to lead is reduced. The finding that the muscles most likely to be affected are those most often used in a person's occupation has led to the classical description of "painters' wrist drop" which affected the muscles of the arm most often used by the painter. If the lead exposure continues at a high level, the muscular weakness spreads and may involve both arms and the shoulder muscles but such cases are now extremely rare.

Tests of the function of the peripheral nerves have been used by a number of investigators in recent years in an attempt to detect neurological damage prior

to clinical effects becoming obvious. There is no consistency in the results of these neurophysiological investigations and in general human cases show no significant decrease in the rate of conduction of the nerve impulse although some workers have shown contrary evidence but in these instances the subjects studied were industrial workers exposed to fairly high concentrations of lead (lead concentrations in the blood above 80 micrograms per hundred millilitres). There is a suggestion in some preliminary work that there are minimal changes in nerve conduction at blood lead levels of about 50 micrograms per hundred millilitres. Such findings are difficult to interpret as they appear not to be associated with any clinical disability.

3.3.7 Lead Encephalopathy

Encephalopathy is an uncommon feature of lead poisoning in adults although it does appear to be more of a risk in the U.S. amongst drinkers of moonshine whiskey but of course in this case the lead intake is complicated often by a high alcohol intake. In contrast to the experience in adults, children with lead poisoning show encephalopathy much more frequently. The dramatic and life-threatening nature of this manifestation of lead poisoning in children is associated with a much poorer prognosis than lead poisoning in adults since the disease in adults is considered to be almost completely reversible upon removal from lead exposure. While there may be some question about the complete reversibility in adults, there can be no question that clinical lead poisoning in children is a medical emergency and that even after recovery from the acute episode the prognosis is clouded by the possibility of permanent brain damage.

3.3.8 Lead Effects on the Kidney

The characteristic finding in the kidney of animals, children and adults poisoned with lead is the intranuclear inclusion bodies in the cells of the proximal tubule. These intranuclear inclusion bodies contain lead and it has been suggested that they may serve a protective role in accumulating soft tissue lead, thus minimizing toxic injury to other cellular components. The number of inclusion bodies in the kidney is dependent on the severity of the lead exposure but is not known to directly affect the functioning of the kidney.

High exposures to lead are associated with functional changes apparently due to damage to the proximal tubule which allows the leakage of amino acids, sugars and phosphate into the urine. While the condition is most commonly found in children, it has been reported in adults. This condition is associated with severe lead exposure and would normally be accompanied by other clinical evidence of lead poisoning.

In the older literature dealing with the effects of lead, there is continual reference to the severe effects on the kidney of long continued high lead exposure. The fact that such effects on the kidney have been disputed in recent years may, in part, be a reflection of the much lower lead exposures of occupational groups. Such effects on the kidneys have been particularly well documented in Australia as the result of long-continued high exposure of children. The Australian experience has been confirmed elsewhere although the incidence of subsequent renal damage of the high lead exposure is less than reported in that country. A follow-up study of lead poisoned children in Boston found that fewer than one percent of the children went on to show

chronic renal damage but the difference between these cases and those in Australia is not only in the severity of the exposure but also in its duration. Drinkers of illicit whiskey in the southern United States commonly show chronic renal damage as part of their disease. Recent studies in industry have shown that contrary to the experience in the 1800's, chronic renal damage is now a rarity.

3.4 Effects of Lead on Behaviour

Clinical lead poisoning is widely believed not to happen when the blood lead concentration is below 80 micrograms per hundred millilitres and as long as the definition of clinical lead poisoning is carefully adhered to there is little information in the world literature that suggests that this is incorrect when considering adults and is probably true even for children although more workers have reported clinical sumptoms at blood lead levels below 80 micrograms per hundred ml in children than in adults. Many of these reported cases, however, when studied in detail show that the blood lead level was not determined at the onset of the illness but at some period after exposure to lead may have ceased. Whether or not clinical lead poisoning occurs at levels below 80 micrograms per hundred millilitres may still be a matter for debate but this debate becomes less important in the face of the information that there is a complete spectrum, from normal through high lead absorption to interferences with the biochemical processes of the body, to changes in structures such as the intranuclear inclusion bodies in the kidney to overt clinical poisoning. As has been shown earlier, heme synthesis may be impaired in the absence of symptoms and thinking in black and white terms is, therefore, out of date and the grey area of subclinical lead poisoning is especially

important now that lead is recognized as a public health hazard. There have been reports, for example, suggesting quite non-specific effects such as inhibition of phagocytosis, mitotic disturbances, shortening of life-span in laboratory animals, effects on the immune mechanism and effects on hormones. It must in fairness be stated that these effects have only been found in cases of very high lead exposure where other evidence of lead toxicity would be expected.

It has been known for many years that lead can affect behaviour although this was particularly connected in adults with the effects of tetraethyl lead in which severe poisoning resulted in a toxic psychosis with hallucinations, delusions and excitement which could end in delirium and death. If, however, the mental sumptoms disappeared, recovery was very likely but a complete return to health might take several months.

The other instance in which lead was known to affect behaviour was the effect of acute lead poisoning in children where brain damage and mental retardation had been recognized to occur in as many as 25% of fully developed cases of lead poisoning.

In recent years attention has been devoted more to the possibility that levels of lead in the body not previously thought to be associated with any effects other than enzyme inhibition may be associated with behavioural changes. Two papers have sought to show that fine motor development, concept formation, some aspects of behaviour and I.Q. were poorer in children with high lead intakes compared with controls with normal lead intakes. In both these papers the criticism can be made that they deal with children with pica and

that children who show abnormal behaviour of this type may also show other emotional disturbances and the high lead intake may be as a result of their emotional disturbance rather than a cause of it. There is no easy way to resolve this type of criticism but, in the case of contamination from a smelter or other general environmental source, the lead level in the child is determined by his distance from the source and not only by his activity. Therefore, these situations may provide a better set of experimental conditions in which to investigate whether lead levels in the range of 40 to 60 micrograms per hundred millilitres of whole blood have any action on the child's behaviour. The paper by Lansdown et al dealing with the Tower Hamlet situation in London found no change in general intelligence, reading ability and rate of behaviour disorder. In the case of the El Paso Smelter, two studies have been carried out and in one hyperactivity was not demonstrated amongst the high lead group and a wide battery of psychometric tests, I.Q. tests and cognant and recognition tests did not show any significant difference between the high lead and low lead groups. The most significant difference was in the California test of personality which is sensitive to disruptive incidents in the child's life which the authors felt the high lead group might reasonably be expected to show because of their geographical isolation as a cultural group, the razing of the townsite where the children lived, as well as their necessary relocation and the exposure of the children to media coverage of the lead situation. In the other study of the El Paso children, neither hyperactivity of the children nor any other behavioural abnormality was significantly more common in either group as measured by the parental questionnaire, the physician's examination or the psychologist's evaluation. Finger-wrist tapping was significantly slower in the dominant hand of children in the high lead group compared with controls but there was no other significant difference in the neurological testing. Comparison of perform-

ance I.Q., however, showed that the high lead group was significantly below the low lead group and that this resulted from the accumulation of small differences in the subtests rather than highly significant differences in any single area. These data suggested to the authors that children with blood lead levels above 40 mcg per 100 ml had diffuse and subtle impairment of the fine motor, perceptual and visual perceptual skills measured by these tests. It should also be pointed out that there was a highly significant difference in the mean age of the two groups and a difference in the number of males and females in the two groups, both of which factors could be expected to affect the types of tests employed.

In a critical review of research on the question of consequences to children with elevated lead levels but without encephalopathy Weiner concluded that the literature was equivocal and that the inability to draw definitive conclusions arose primarily from methodological shortcomings. Chisolm and Kaplan in their review of the consequences of childhood lead poisoning indicate that the relationship between disfunction, incognitive behavioural and social performance and overt encephalopathy is uncertain. Furthermore, these relationships are complicated by the observation that the symptom clusters do not necessarily remain stable. For example, as puberty approaches, some behavioural problems such as aggressiveness may "mature off". Unfortunately, it is also possible that new problem behaviours may emerge from unspecified developmental processes as is sometimes seen in children diagnosed as suffering from minimal brain disfunction.

At this time there appears to be no clear evidence that behavioural changes do occur in children where blood lead levels have never risen above 50 to 60

micrograms of lead per hundred ml of blood but further studies along the lines suggested by Barocas and Weiss are certainly indicated.

3.5 Environmental, Including Biological, Effects of Lead Smelters

3.5.1 Survey of Published Information on the Environmental Effects of Lead Smelters - Jugoslavia

At the Mezica mine, situated in the valley of the Meza River near the Austrian border, about 600 metres above sea level is a mine that has been worked for about 300 years. Despite its high altitude, the mine is surrounded by high mountains up to 1,624 metres forming a basin in the centre of which is a smelter. The smelter was built in 1746 and was producing about 2,500 tons of lead annually by 1850. After 1900 production increased and is now about 22,000 tons annually. There were no pollution abatement devices used at the smelter until 1969 and the land, water and vegetation in the valley have become severely contaminated with airborne and waterborne lead from the smelter complex. Suspended air lead levels in communities around the smelter reached levels as high as 84 micrograms of lead per cubic metre of air and were frequently above 60 micrograms of lead per cubic metre of air. Water in the Meza River immediately below the smelter showed lead levels of 685.12 milligrams per litre of water and in the Meza River close to its mouth, 22 kilometres from the smelter, the lead level was 2.89 milligrams per litre. Lead levels in the soil in the communities ranged from 295 milligrams per kilo to 24,800 milligrams per kilo. Aminolaevulinic acid levels in the urine of persons in the villages within the mining area averaged 11 milligrams per litre of urine with a range from 0.7 to 44 milligrams per litre in six different villages comprising a total of 912 persons tested. Similar measure-

ments made in a control group of 50 persons from an uncontaminated area showed a range of ALA excretion in the urine from 0.35 to 8.55 with a mean of 5.2. Seventy men working in the lead smelter showed a range of ALA excretion from 7.5 to 117 milligrams per litre with a mean of 54.4. The contamination of hay harvested for fodder in the area showed a range from 120 to 430 parts per million compared with 10 ppm from an uncontaminated area.

At another smelting complex near the village of Male Rudare which is adjacent to the Trebca Smelter complex, 71 women and children had blood lead levels determined and these ranged from 37 to 70 micrograms per 100 grams of whole blood, with the average value being 49.3. A control study carried out among residents of Belgrade, the capital city of Jugoslavia, showed the lead level to average 37.6 micrograms per 100 ml, while amongst peasants living around Belgrade the average value was 31. These levels, which would be considered high for an urban population in North America, may raise some question about the analytical technique. The lead levels in the urine of the 71 women and chilren examined at Trebca had an average lead level of 135 micrograms per litre, whereas the average of the Belgrade residents was 40 mcgs per litre. The lead in the air of Male Rudare had an average level of 117 mcgs per cubic metre with a range of 59 to 136 mcgs. The sampling site was some 750 to 1,000 metres from the main stack of the smelter complex. Lead levels in the surface layers of the soil in the village were found to be 141 milligrams per 100 grams of soil, whereas at a depth of 30 centimetres it was 22 milligrams per 100 gms and in a park in Belgrade, taken as a control area, it was 0.35 milligram per 100 grams; dust from the roof of one of the houses in the village showed a level of 252 milligrams of lead per 100 grams of dust. Cheese made from cow's milk in the village had a lead level of 124 micrograms per 100 grams and it was reported that

domestic animals such as sheep perish because of high lead absorption when grazing in the area of the smelter. References: the first report was published in Archives of Environmental Health, Vol. 22, October 1969 by Djuric, D. et al. The second report was published in Higijena, Vol. 12, No. 1, Belgrade 1960 by Djordjevic and Stankovic.

3.5.2 Lisle, France, of an Electric Storage Battery Plant

The authors of this study, J. Dquidt and Vaast, published in Pollution Atmospherique, Vol. 13, No. 52, October-December 1951, pages 289-292. These authors studied children between the ages of 12 and 14 attending a school located near the vicinity of the battery plant. Twenty-four students were studied and were compared with 25 children who had resided for a least two years in an area away from any known lead pollution. The levels of delta aminolaevulinic acid in the urine of the exposed children had an average of 4.4 milligrams per litre with a range of 2.77 to 2.66 while the control group had a mean of 1.78 with a range of 0.8 to 2.8 milligrams per litre. When the relative frequency of the different delta aminolaevulinic acid determinations were plotted in the two groups, there was a pronounced shift to the right of the exposed group. No environmental measurements of lead were included in the paper and none of the school children showed clinical evidence of poisoning. In a paper by DeRosa and F. Gobbato published in Igiene Moderna, Vol. 63, No. 1, pages 472 to 484, 1970, three epidemics of lead poisoning in Chile are referred to in the preamble to the paper, the first occurring among the inhabitants of a small village on the banks of the River Mapochi where an old plant for the extraction of gold from sand and gold ore was located. The second epidemic was reported at one of the lakes of southern Chile close to a lead mine; amongst the many cases of lead poisoning

recorded were 52 children below the age of 15 years. A third epidemic of less magnitude occurred amongst the residents of a small community in the proximity of a plant for the fusion of lead. The number of people involved was limited since the residential area was upwind from the plant. The authors of this particular paper were inclined to attribute the poisoning to the consumption of food and vegetables contaminated with lead. In the main part of the paper an epidemic of lead poisoning is described in Stanghella, a small town in the County of Padova. A small plant had recently been established in this community for the recycling of lead from the melting of old car batteries. A total of 170 people were examined, all living within a radius of 300 feet from the plant. Twenty percent of the persons in the survey had urine lead levels above 90 micrograms per litre and 2.8% had levels above 210 micrograms per litre. While no clinical information is given in the paper, two thirds of the population sampled had increased free erythrocytic protoporphyrin levels and one third had definitely elevated urinary coproporphyrins.

3.5.3 Chile

A paper by Hernan Oyanguren in the Archives of Environmental Health, Vol. 13, August 1966, pages 185 to 189, gives information on a group of workers engaged in extracting sand and gravel for construction purposes who lived with their families in a number of shacks located on yellow clay soil along the shores of the river. They drew water for their domestic use from shallow wells, each family using a separate well. Retrospectively they stated that some small children who played and crawled about on the ground had died with convulsive attacks and they also remembered that some domestic animals had died in convulsions. The first clinical study was made by Dr. Manterola on a 4-year-old child who since his

second year had had intermittent convulsive episodes and was admitted to hospital in 1957 with polyneuritis. During his stay X-rays of the long bones revealed dense transverse bands of the metaphyses such as those induced by the absorption of lead. Lead poisoning was suspected and analysis of the blood showed a blood lead level of 120 micrograms per 100 grams of whole blood. The environmental observations revealed that the average concentrations of lead in the water in the wells was 408 micrograms per litre, while that in the soil was 11% of which 0.42% was soluble. A second series of studies was started in 1958 and involved 58 children. Results of investigation in hospital showed an average blood lead level of the children of 47 micrograms per hundred grams of blood with a range from three to 108 mcgs with 8 of them exceeding 80 mcgs per 100 ml of whole blood. The hygienic problem was finally solved by moving the families and fencing off the contaminated land. In January 1959 a study was made near a lead smelter under very deplorable conditions. The occupational exposure was so severe that cases of lead poisoning had been induced out of periods of exposure as brief as 28 days while the average period was 80 days. Prevalence of lead poisoning amongst 20 workmen who were employed at that time was 45%; three healthy men found in this survey had only been employed for 10 days prior to the investigation. The children of the workers used to play in the vicinity of the smelter and they ate wild fruit coated with dust. During the period of the investigation one child of 5 years developed convulsions. Samples of blood and urine were also obtained from members of another family which, like the first, lived within 300 feet of the plant. The results of the determinations on the samples from the four persons in this family were positive, 4 urine coproporphyrins, and showed lead levels of 183 and 103 mcgs per 100 grams of whole blood for two children aged 6 and 9, and elevated but not dangerously so in the mother and the 15-year-old daughter, both of whom had a level of 62 mcgs per hundred grams of

whole blood. The child with convulsions died after 36 hours with convulsions terminating in coma. The authors of this report noted that the children had greater and more frequent opportunities for the ingestion of lead than had the mother and the older daughter.

3.5.4 England - Isle of Dogs - Tower Hamlets

In 1971 proposals to redevelop the area near the lead refinery in Tower Hamlets were viewed with a certain amount of caution and the local medical officer of health instituted tests to measure concentrations of lead in the air and rate of deposition of lead and lead compounds on the ground in the vicinity of the refinery. This survey extended over a period of some 6 months and the mean value over the whole period for atmospheric lead concentration was 3 micrograms per cubic metre, but concentrations up to 92 mcgs per cubic metre were observed for three-hour periods. In comparison concentrations measured over 24 hours on a control site with no associated lead problem ranged from 0.6 to 1.9 mcgs per cubic metre. The lead content of the dust collected from window ledges close to the refinery ranged from 2,500 to 32,000 ppm and in gutters from 1,000 to 38,000 ppm. Lead in the soil near the works at Tower Hamlets gave concentrations between 1,400 and 14,000 ppm but it must be remembered that smelting and refinery operations have been in operation on this site for over 100 years. Epidemiological surveys of people living in the vicinity of the lead works were carried out by local authorities in collaboration with the Department of Health and Social Security. At Tower Hamlets it was found that 40.9% of the children under 5 living between 100 and 400 metres from the factory had blood lead levels in excess of 40 mcgs per 100 ml compared with 12% of the mothers in this range. Between 400 and 500 metres from the plant, 13.7 of the children but none of the mothers were

above the 40 mcg ml limit. It was established that the children of lead workers were expecially at risk, the lead being taken home in clothing or on shoes.

3.5.5 Suffolk

The situation at Suffolk was exposed in a similar way to that described above; no lead in air concentrations are available but dust deposition close to the works gave lead concentrations from 2,000 to 300,000 ppm, the highest level being at the works entrance less than 50 metres from the centre of the works. In children living within 225 metres of the works, 59% had blood lead levels above 40 mcgs per 100 ml and at 225 to 400 metres, 53%, while at 450 to 675 metres 49% and at 900 to 1127 metres, 45% of the children had blood lead levels above 40 mcgs. The comments from the Department of the Environment's official in England stated that in the case of people living in the vicinity of lead works, it is more difficult to define precisely the pathways by which excessive lead reaches the family. Some dust may be taken out of the factory on footwear and on clothing or on the wheels of vehicles leaving the works and subsequently spread by turbulence in the wake of passing traffic. Some may be windborne from the factory's scrap yard and stock pile, and some of the fine residual dust emitted by the factory's chimney after filtration may be inhaled directly. All of these factors were probably significant and merit attention. Children with markedly raised blood lead levels were referred to their family doctors and, where appropriate, for further medical investigation. In no cases were any symptoms of lead poisoning observed. In the case of the Tower Hamlets area, a special study was conducted by the Hospital for Sick Children, Great Ormond Street, London, in which the total population of children under the age of 17 living in the neighbourhood of the plant were studied;

of the 275 children thus available, intelligence testing was carried out on 232 or 84%; teachers' ratings of behaviour were obtained for 227 or 82% and health visitor information was obtained for 218 or 79%; only one percent of parents refused to allow their children to take part in the study. A positive correlation was found between the children's blood lead levels and their current address, showing that there was a greater likelihood for those living near the factory to absorb greater amounts of lead. No relationship was found between lead level and either intellectual development or generally deviant behaviour or over-activity in school. The authors of this paper, Lancet March 30, 1974, R.G. Lansdown et al, pages 538 to 541, made the comment "Our findings apply to a situation where exposure to lead was determined by factors extraneous to disturbance in the child or family, i.e., by the distance of the place of residence to a contaminated area. In a different situation where a number of children are exposed to roughly the same quantity of lead, it is quite likely that those who are disturbed will, because of inappropriate feeding habits, ingest larger quantities and show higher blood lead levels. This would explain the findings of David et al, Lancet 1972, Vol. 2, page 900, who found hyperkinetic children to have higher blood lead levels than non-hyperkinetic controls. These workers attempted to show that where another explanation existed for the hyperkinesis lead levels were lower but in fact the numbers in their known cause group were not sufficiently high to draw this conclusion. The findings of Bird and Coat, Journal of Pediatrics 1972, Vol. 81, page 1088 who found a group of children with pica to have poorer fine motor control and greater degrees of psychological disturbance than matched controls without pica are readily explained on the basis of the fact that if a child has one sign of emotional disturbance, pica, he is much more likely to have other signs of disturbance. There are, however, limitations to the present study which should be made clear. It is possible that mild exposure

to lead has an effect in children younger than those we tested. Because of the unreliability of psychological testing below school age we did not examine the children under 5 in this way. If there is an effect on under-5's, it is likely to be only a temporary one because we found no evidence to suggest that children who had spent the first two years of life in an area of high exposure were mentally impaired later in life. However, even temporary impairment, if demonstrated, would be no light matter. Secondly, it is possible that the psychological tests carried out were not sufficiently subtle to demonstrate the effects of toxicity. This is rather unlikely since the tests did, in fact, tap quite a wide range of abilities - verbal and visu-spatial."

3.5.6 Finland

In this study published in Work - Environment Health - Vol. 10, 1973, pages 19-25 Dr. Nordman et al found that a population living in the vicinity of a secondary lead smelter in southern Finland showed moderately elevated lead levels in persons living closer to the plant compared with those living further away from it. The range of values, however, was only from 13.6 mcgs per 100 ml to 24.1 mcgs ml in the males and 10.6 to 19.1 mcgs per 100 ml in the females. A statistically significant correlation was obtained between the blood lead levels of people living in the area of the smelter with the levels of dustfall from the smelter but in this paper no reference is made to the suspended lead levels in the air which might be expected to vary in a somewhat similar fashion to the dustfall and it would, therefore, not be possible to separate the effect of the suspended lead in air from any effect of dustfall on the blood lead concentration.

3.5.7 United States - El Paso

In the City of El Paso, Texas, there is situated a custom smelter, smelting lead, copper and zinc materials, the raw material coming from a wide variety of sources in the United States, Canada, Mexico and Australia. The great majority of the lead emissions come from an 823-foot stack which serves three copper converters, while the lead plant has a 612-foot stack but all emissions pass through a bag-house prior to entering the stack. Late in 1970 it was discovered that emissions from the smelter contained extremely large quantities of lead, cadmium, zinc and arsenic. Lead emissions were the greatest with the known quantities being 511 tons in 1970 reducing to 313 tons in 1971. When this information was brought to the attention of health officials they initiated tests for blood lead concentration in the residents of areas surrounding the smelters. These tests indicated that in 520 individuals of all ages, 223 of whom lived within one mile of the smelter, 163 between one and two miles and 134 living more than two miles from the smelter there were many elevated blood lead levels. Within one mile of the smelter nearly 70% of children aged 0 to 5 years had blood lead levels greater than 40 mcgs per 100 ml, while between one and two miles from the smelter only 25% of such children had elevated levels and greater than two miles from the smelter no children were found to have levels above 40 mcgs per hundred ml of whole blood. These blood lead levels were paralleled by the surface soil lead concentrations which reached 10,750 ppm close to the plant and fell in an exponential fashion to mere traces in northeast El Paso. Downwind from the smelter suspended air lead concentrations reach 47 mcgs per cubic metre, while upwind from the smelter the figure was 7 mcgs per cubic metre. Within one mile of the smelter the suspended air levels had fallen to between 1 and 2.5 mcgs per cubic metre.

Although many of the children showed evidence of lead absorption, as characterized by their blood lead levels, free erythrocytic protoporphyrin levels and X-ray evidence of bone changes due to lead. There was no clinical evidence of lead poisoning in any of the children examined at El Paso. Two studies have been carried out which have concentrated on the neurological and behavioural findings in the children and these are dealt with under the effects of lead on behaviour.

3.6 Summary of the Effects of Lead Smelters on the Environment and the Population in Their Vicinity

It can be seen from the examples quoted above that smelters can and do affect the environment by causing raised levels of lead in the air, soil, vegetaion and, where present, animals and human beings. The effects on human beings may be merely a change in lead level in the blood depending on whether a person lives close to the smelter or further away from it or the lead levels in persons close to the smelter may be so high as to give rise to clinical illness as in the cases in Chile.

It must be remembered that in some cases the smelters in the incidents cited were relatively isolated and no other major sources of lead contamination occurred in the vicinity, while in other instances a smelter was situated in a downtown area where other sources of lead emissions would have to be taken into account in assessing the effect of the smelter on the environment and human lead levels.

In evaluating the hazard posed by the levels of lead found in any population group at least two pieces of information are required. The first is a series of events which can be reasonably expected to happen in people at lead levels ranging from the lowest to the highest that might be encountered in the population.

The second piece of information consists of reliable measurements of the lead levels in the population. Given such information it would be possible to evaluate the degree of hazard to the group as a whole and also to individual persons comprising the group.

Unfortunately, the present knowledge of the effects of lead on man is still imperfect and, therefore, on some of the most crucial questions there is a difference of opinion on the health significance of a particular finding. The public sometimes expresses concern that after living with lead for several thousand years there are so many unanswered questions about the actions of lead in the body. This situation would probably not have occurred if society had not, understandably, kept raising its expectation with regard to human health or science had not continuously improved and developed its ability to detect and measure events within the body.

At one time the most pressing problem with regard to lead was to reduce the number of deaths from lead poisoning in the lead trades. With the knowledge of how to prevent deaths there was pressure to control the large amount of illness which was associated in working with lead until today the goal is that no one's health should be jeopardized by his occupation and within the last few years society has asked that no one's health be involuntarily jeopardized by his

environment, whether on or off the job.

Coupled with these increasingly high demands from those charged with protecting the public's health has been the tremendous upsurge in the scientists' ability to measure minute changes in the body and within individual cells of the body. Often the scientists' ability to make a value judgment as to whether a certain observed change is good, bad or unimportant has not caught up with the tremendous increase in his ability to measure increasingly small changes.

It is likely that, with any substance such as lead which is not known to be necessary to the body, the body passes through a number of phases as the lead level rises. At first the lead level will be in a range which can be considered "normal" and for early man this was probably less than 10 mcgs of lead per 100 grams of blood. Since this range of blood lead levels was entirely derived from man's environment prior to any addition of lead due to man's activity, it is reasonable to assume that any effect that it has on man can be considered "normal" just as sunlight can have some effects on health but is considered a "normal" environmental stress. In modern man the blood lead values in men and women far removed from local sources of lead contamination such as the headwaters of the Amazon, the Kalahari Desert and remote portions of Australia range from a group average of 12 mcgs per 100 gms to a group average of 23 mcgs per 100 gms. All of these values were determined by the same laboratory and the total number of individuals sampled was 204. These values overlap those found in urban groups in Ontario (see Table I).

TABLE I

Blood Lead Level in mcg Pb/100 gm blood	Rural Town (adults)	Toronto Suburb (adults)	Toronto Downtown (office workers)
0 - 5	7	2	3
6 - 10	9	6	10
11 - 15	12	17	17
16 - 20	5	15	14
21 - 25	5	6	4
26 - 30	1	3	3
31 - 35	0	2	0
36+	0	0	1
Number of Persons:	39	51	52
Average Blood Lead Level:	12.5	16.6	14.7

At levels of lead found in present residents of Ontario and the postulated levels in their primitive ancestors there would be a measurable reduction of one of the enzymes (ALA dehydrase) that is involved in the early stages of the building of the heme portion of the hemoglobin molecule.

Some scientists have viewed this minimal degree of inhibition as a harmful (Epstein) but on balance those scientists who have made a particular study of this matter have concluded that a minimal change in the activity of ALA-D in the circulating red cell has no relevance in terms of human health (Hernberg, Zielhuis, Airborne Lead, page 127). As the blood lead level rises beyond about 40 mcg Pb/100 gm blood there is evidence that the depression of the enzyme ALA-D is causing a backing up of chemicals that would normally be used to form

hemoglobin. This evidence consists of an increase in the amount of ALA in the urine and as blood lead levels rise above 40 mcg/100 g blood urinary ALA excretion rises at a progressively increasing rate until at about 60 mcg Pb/100 g blood the ALA level in the urine of most adults is clearly above the range found in the general population.

There is little evidence that there is any significant effect on health where the blood lead level has not risen above 40 mcg/100 g blood. At blood lead levels between 40 and 60 mcg/100 g there is evidence of increased lead absorption from some source, or sources, in the environment. In this range there may be effects on behaviour in pre-school-age children (David) but the findings in several of the studies that claim to have shown such effects are disputed and there are other studies using different methods of evaluating behaviour which claim no demonstrated effects at the blood lead levels in question. Studies in animals have not, in general, been of great assistance in helping to resolve the questions surrounding the behavioural effects of lead because the doses of lead used have usually been so high that other evidence of lead poisoning would be expected (Silbergeld) (Airborne Lead page 160) (Subclinical Effects of Lead page 129). There are, however, a few experiments in animals using levels of lead which can be considered realistic which support the concept that levels of lead in the 40 to 60 mcg/100 g blood range may, particularly in young animals, have an effect on behaviour (Carson) (Gusev) (Airborne Lead page 162). In the experiments by Carson, exposure of pregnant sheep to lead which produced an average maternal blood lead level of 34 mcg/100 g blood give rise to slowed learning in the offspring when tested at 10-15 months of age. No such effects were found in lambs from two groups of ewes where the average blood lead level was 5 and 18 mcg/100 g respectively.

Thus, taking into account all of the evidence available at this time, there is general agreement that confirmed blood lead levels above 40 mcg/100 g indicate increased lead absorption and require a careful search for the cause. In children the possibility of behavioural effects of lead levels above 40 mcg/100 g makes it prudent to consider measures to reduce lead absorption so that blood lead levels above this figure become increasingly rare. At blood lead levels of 50 mcg/100 g blood there is general agreement that children should be referred for immediate evaluation by a physician (U.S. Surgeon General). Such advice is based on the impossibility of knowing whether a single blood lead level represents a concentration of lead that has been constant for some time or represents a point on a rapidly rising curve due to recent high lead absorption. In the latter situation there may only be a short interval between the reception of the first blood lead report and the onset of clinical lead poisoning due to the continued increase in the blood lead level. For this reason, coupled with the grave nature of fully developed lead poisoning in children, it has been considered wise by pediatricians to place children under medical care when blood lead levels of 50-60 mcg/100 g blood are encountered. If, after full evaluation of all the circumstances it is found that the blood lead level is not rising, many pediatricians would adopt a watchful approach rather than recommending immediate treatment but this must be a matter for individual judgment by a physician conversant with all the facts.

Since public health deals with preventive medicine it seems reasonable that the aim of public health officials should be to ensure as far as they are able that the blood lead levels of children are maintained well below levels that pose a health hazard. In this context it would seem reasonable to hold that a blood lead level that requires referral to a physician for possible treatment is a level posing a

health hazard. If, then, a level of about 50 mcg Pb/100 g of blood is taken as being unacceptable in the general public, the question immediately arises as to the upper limit that can be considered acceptable at this time. It has been seen from previous discussions that at blood lead levels of about 40 mcg/100 g of blood biochemical changes can be shown in the body which are associated with an interference in the manufacture of hemoglobin. At this time the body is thought to be able to compensate for this minimal degree of interference without deleterious effects. Such compensatory mechanisms are common in the body and reflect the usually considerable reserve capacity present in most organs of the body. Therefore, in the light of present knowledge, confirmed levels of lead in the blood up to 40 mcg/100 g can be considered acceptable.

It is of the utmost importance to realize that in setting administrative or operational guidelines, artificially rigid lines are being drawn and that the numbers mentioned do not represent sharp points separating safe from unsafe. The biological effects of lead appear to run smoothly and continuously from levels of lead which are clearly without effects on human health to levels carrying a high probability of a fatal outcome.

If now we turn from a consideration of the effects of lead on health and the setting up of guidelines for action to the question of the levels of lead found in the populations surveyed in Ontario we find that the guidelines selected are consistent with the finding of problem areas.

In the figures quoted for blood lead levels of groups in Ontario it is rare to find levels above 40 mcg/100 g blood and this has been the general experience of investigators throughout the world (Zeilhuis), if an exception is made for studies of groups with special risks of lead absorption such as children in dilapidated inner-city housing. In the control area of Toronto that was selected to be as being similar in respect to housing, ethnic makeup and socio-economic status as the areas close to the lead plants, 863 persons were surveyed and only 3 values equal to or greater than 40 mcg/100 g blood were found. Thus, for reasons that are presently the subject of intensive analysis, lead levels above 40 occur more frequently in the vicinity of the lead plants than in other areas of Toronto which have been surveyed using similar methods. Also, these elevated blood lead levels appear to be more common close to the plants compared with persons sampled who live further away. Children show more of the elevated levels than do women resident in the same area but there is some evidence that adult males in the working age group also show a significant number of blood lead levels above 40 mcg/100 g. Therefore, it appears that some environmental factors in the neighbourhood of the lead plants so far studied are resulting in elevated blood lead levels. The fact that these elevated blood lead levels do not affect everyone close to a plant suggests there are local or individual reasons that operate in conjunction with the general environmental contamination with lead to cause any particular individual to have blood lead levels above 40 mcg/100 ml. These local or individual reasons might include high levels of lead in house paint combined with pica in children or occupational exposure to lead in adults. The vast mass of data accumulated by the City of Toronto Health Department, the Ministry of the Environment and the University of Toronto has only just begun to be analyzed and so all of the findings presented in this report

that relate to blood lead levels or the household lead environment must be treated as very preliminary and, although believed to be true at this time, are subject to modification in the light of the results of the full analyses.

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4. AIR QUALITY STANDARDS, CRITERIA & OBJECTIVES FOR LEAD

4.1 Introduction

Air quality standards criteria and objectives for lead are based on preventing adverse health effects due to lead exposure in the general population.

Since the data relating low level lead exposure and subclinical effects are inconclusive and are the subject of considerable investigation at this time, the standards, criteria and objectives based on medical grounds are in a state of fluidity and are the subject of considerable differences of opinion.

The evidence presented here in support of air quality standards criteria and objectives is open to argument but, it represents the current body of opinion of the major air pollution control agencies in North America and the data presented are taken from airborne lead in perspective as extracted by a committee of scientists convened by the U.S. Environmental Protection Agency to consider the relationship of environmental lead and human health.

Environment Canada has also prepared an internal report on "Recommended Air Quality Objectives for Lead", which is reviewed in Section 4.3.

4.2 Lead Exposure and Health Effects as a Basis for Air Quality Standards, Criteria & Objectives (E.P.A.'s Position)

4.2.1 Suspended Lead

As outlined in Sections 1 and 2, lead occurs naturally in most living things including humans. Blood lead levels above 80 ug/100 ml of whole blood may be associated with symptoms of clinical lead poisoning in adults.

The threshold limit value for occupational exposure to lead is 150 ug/m^3 and is aimed at preventing acute lead poisoning based on an 8 hour day and 5 day week.

The U.S. Environmental Protection Agency presented a summary of the known health effects of lead absorption. (Table III-1).

4.2.2 Relationship Between Exposure and Absorption of Lead

Based on the known health effects of lead absorption, the Environmental Protection Agency have concluded that a level of 40 ug/100 ml of lead in blood is the maximum tolerable level of lead absorption. However, the relationship between exposure to respirable lead and intake as indicated by blood lead levels is not quantitively determined since intake by ingestion is a complicating factor which makes separation of the source of lead absorption difficult.

The Environmental Protection Agency committee has concluded based on the data of Kehoe, that a continued daily lead ingestion of 600 ug could cause blood lead levels to rise above 40 ug/100 ml. Normal dietary intake is reported to be from 200 to 300 ug/day.

The daily amount of lead absorbed from inhaled air is the product of the airborne lead concentration, the volume of air respired, and the percentage absorption of the lead.

TABLE 4-11 Level and Types of Effects of Inorganic Lead Salts as Related to Estimates of Various Levels of Absorption – Recent and Remote

Type of Effects	Level I: No Demonstrable *in vivo* Effect	Level II: Minimal Subclinical Metabolic Effect	Level III: Compensatory Biologic Mechanisms Invoked	Level IV: Acute Lead Poisoning – Mild	Level IV: Acute Lead Poisoning – Severe	Level V: Late Effects of Chronic or Recurrent Acute Lead Poisoning
Metabolic (accumulation and excretion of heme precursors)	Changing ALAD[a]	Slight increase in urinary ALA may be present	ALA, UCP, FEP progressively increased	ALA, UCP, FEP increased 5- to 100 fold		Increased if excessive exposure recent, but may not be increased if excessive exposure remote
Functional injury:						
Hematopoiesis	None	None known	Shortened red-cell life-span, reticulocytosis (±) (reversible)	Shortened red-cell life-span and reticulocytosis with or without anemia (reversible)		Anemia (±) (reversible)
Kidney (renal tubular function)	None	None known	?	Aminoaciduria, glycosuria (±) (reversible)	Fanconi syndrome (reversible)	Chronic nephropathy[b] (permanent)
Central nervous system	None	None known	?	Mild injury (??? reversible)	Severe injury (permanent)	Severe injury[b] (permanent)
Peripheral nerves	None	None known	?	Rare	Rare	Impaired conduction (wrist, foot drop usually improve slowly, but may be permanent)
Clinical effects	None	None known	Nonspecific mild symptoms (may be due in part to coexisting diseases)	Colic, irritability, vomiting	Ataxia, stupor, coma, convulsions	Mental deficiency (may be profound), seizure disorder, renal insufficiency (gout) (permanent)
Index of level of recent or current absorption:						
Blood lead, μg/100 g of whole blood	<40	40–60	50–100+	>80 With anemia, intercurrent disease: 50–100+	>80	May be normal
Urine lead (adults only), μg/liter	–	<80	<130	>130 (May be less in severe illness)	>130	Spontaneous excretion may be normal

[a]See p. 106 for discussion of changing levels of ALAD

[b]CaEDTA mobilization test in chronic nephropathy is positive; may or may not be positive in permanent central nervous system injury

Taken from E.P.A.'s Position on Health Implications of Airborne Lead

For a standard man (70 kg. weight, 20 - 30 years old, 175 cm. tall with a surface area of 1.8 m^2), the respiration rate is quoted as 23 m^3/day for light work.

The E.P.A. gave estimates of airborne lead levels which would cause daily lead intake to reach 60 ug/day.

Table V-4 (From E.P.A.'s Position on Health Implications of Airborne Lead)

Common Daily Dietary Lead Absorption	Increase Required to Reach 60 ug Daily +	Airborne Lead Exposures Which would Cause the Designated Increase		
		Standard Man (a)	Least Case(b)	Highest Case (c)
20 ug	40 ug	6.7 ug/m^3	15.7 ug/m^3	5.4 ug/m^3
30 ug	30 ug	5.0 ug/m^3	11.8 ug/m^3	4.0 ug/m^3

\+ Experimentally in a human, absorption of 60 ug of lead daily caused his blood lead levels to reach 40 ug/100 grams of whole blood (Kehoe)

(a) Standard man = 20 m^3 x 30% absorption

(b) Least Case = 15 m^3 x 17% absorption

(c) Highest Case = 20 m^3 x 37% absorption

Qualification of the foregoing:

- these data are based on limited experimental findings and are only an indication of the relationship for one subject.

- the variability of absorption by the general population may alter the reliability of these quantitative data.

- there are no conclusive data to support that 40 ug/100 ml of whole blood is the maximum tolerable blood level for all sections of the population.

- if normal dietary intake is significantly exceeded, air lead levels would have to be much lower.

- the absorption of lead by children is known to be greater than by adults relative to body weight.

- the level of absorption may also be dependent on the chemical nature and physical state of the lead.

If the qualifications are accepted, it can be seen that airborne lead levels of about 5 $ug/m^3/24$ hours should be tolerable for the general adult population with normal dietary intake.

4.3 Environment Canada's Report on Air Quality Objectives for Lead

The Atmospheric Environment Service of Environment Canada, in a recent internal report, have taken a stronger line than the E.P.A. regarding a maximum tolerable blood lead level and concluded that a level of 30 ug/100 ml was desirable for the general population based principally on a margin of safety below the level of 400 ug/100 ml at which the first known effects of lead absorption have been found.

Based on the exposure intake data of Kehoe and Goldsmith and Hexter, the following conclusions were made regarding an objective for lead in ambient air.

No objective or guideline is proposed for lead in dustfall although this is recognized as contributing to human lead exposure.

Conclusions from Environment Canada "Report on Air Quality Objectives for Lead"

1. For children inhaling about 6 m^3/day the amount of lead inhaled is negligible compared to the amounts ingested.

2. As the volume of inhaled air increases the contributions of lead from the air increases in importance.

3. A concentration of 5 ug/m^3 would seem to be adequate to maintain the adult blood lead at or below 30 ug/100g.

4. If the assumptions on which our calculations of blood lead levels for children are correct, then a concentration of 5 ug/m^3 would appear to be adequate to maintain blood lead levels of most children at or below 25 ug/100g.

5. An ambient air quality objective of 5 ug/m^3 based on a 24-hour average is therefore recommended.

6. If the dietary intake of lead is increased in localized areas, then the air quality objective may need to be more restrictive to protect that segment of the population.

7. A more stringent air quality objective may be needed to protect children who tend to ingest non-food material such as paint and dirt, particularly if these non-food materials have high lead concentrations.

8. In the cases of high lead ingestion it is more sensible and effective to control the concentrations of lead in the ingested materials than in the air.

4.4 Lead Exposure from Lead in Dustfall (Indirect Ingestion)

The assumption that 5 ug/m^3/24 hours is a tolerable lead level only holds for a normal dietary intake of 200 - 300 ug/day.

Settleable lead particles as measured by lead in dustfall contribute to lead contamination of dust and dirt in streets and in homes, and also to levels of lead in the soil and vegetation. This lead is available for ingestion by humans and is supected of being an important source of lead intake for children. Weathering of leaded paint from buildings is a further important source of available lead by contributing to contamination of dirt and dust.

Lead in dustfall decreases with distance from roadways and lead processing plants as do the levels of lead in soil and vegetation.

In order to limit the available lead in the Environment, it is desirable to set a criteria for lead content of settleable particles as measured by lead in dustfall.

The possible bases for such a standard are:

1. Limitation of Combined Ingestive and Respired Lead Intake to Less than 60 ug/day

   - there is insufficient data to directly relate lead in dust, dirt and soil blood lead levels.

2. Limitation of the Rate of Soil and Dust Contamination

- the maximum rate of soil contamination by lead in dustfall can be calculated, but no direct relationship between lead in dustfall and soil and dust contamination has been found.

3. Levels of Lead in Dustfall in Urban Areas Remote from Sources of Lead? (Background Base Level)

4. The Ratio of Inert Particulate to Lead in Suspended Particulate Standards.

- since the effects are different, this is not a good guide.

While there is no direct determined relationship between ingestion of dust, dirt and soil contaminated with lead and blood lead levels due to the widely differing availability of the lead, the E.P.A. quoted studies of increased blood lead in rats fed with soil from around the El Paso Smelter and dust from city highways.

The National Academy of Sciences' Lead Panel concluded that "The swallowing of as much as 7 grams of such dust could result in the oral intake of an amount of lead that exceeds by a factor of 10 or more the estimated mean daily intake of lead from normal food and drink in non-exposed children."

4.5 Evidence of the Need for Air Quality Standards Criteria and Objectives for Lead

Data gathered in studies in the United States and Europe have indicated that a small, but significant, proportion of the general population, particularly children, have blood lead levels in excess of 40 ug/100 ml.

Problems still exist with chemical analysis of blood for lead content and the relative contributions of dietary intake and air are not quantitatively determined.

Certain occupational groups exposed to high ambient air levels from automotive sources shown an increased incidence of blood lead levels over 40 ug/100 ml and from 5 to 45% of children in 24 recent studies had levels in excess of 40 ug/100 ml.

The Environmental Protection Agency (E.P.A.) concluded that:

"A small, but significant, fraction of the adult population has blood lead levels of 40 ug/100 ml or higher and such levels occur in a much larger proportion of urban children. Such levels are medically undesirable and should be reduced if possible."

"Sources of exposure to lead include food, water, air and ingested non-food items such as lead based paint and dust. Food is the largest contribution of lead to the general population."

"Lead based paint is a major cause of overt clinical poisoning in children though sources of lead other than paint play an important role in childhood lead, particularly at levels below overt poisoning."

"Lead in dust and dirt is believed by the E.P.A. to contribute to increased lead levels in man both through inhalation of suspended dusts and at least in children through inadvertent ingestion of dirt and dust. This source could significantly reduce the additional quantity of additional lead required to produce clinical poisoning in a child with other sources of exposure. Automotive lead is a major contributor to lead in dust and dirt and has been related to undue absorption in children."

TABLE VII-1

Extent of Abnormally Elevated Blood Leads
Among Urban Adults

City	Exposure Category	Number Studied	% of Blood Leads Equal to or Greater than 40 μg/100 g
Cincinnati	Post Office Employees (4)	140	2.9
	Firemen (4)	191	3.0
	Service Station Attendants (4)	130	12.3
	Police (4)	40	12.5
	Drivers of Cars(4)	59	15.0
	Parking Attendants (4)	48	44.0
	Garage Mechanics (4)	152	67.0
Los Angeles Area	L.A. Police (4)	155	0.6
	Pasadena Male City Employees (4)	88	3.3
	L.A. Female Aircraft Employees (4)	87	3.3
	L.A. Male Aircraft Employees (4)	291	5.2
Philadelphia	Male Commuters (1)	43	2.3
	Police (4)	113	3.5
	Downtown Male Residents (4)	66	4.5
Camden, New Jersey	Women Living Near Freeways (5)	55	1.8
Composite Urban Samples	Females from New York, Philadelphia, and Chicago (3)	423	0.7
	Males and Females from 6 Cities (3)	833	2.7*
Composite Urban Samples	Taxi Drivers and Office Workers from L.A.; Philadelphia; Barksdale, Wisconsin, and Starke, Florida (6)	149	0

*Only those above 40 μg/100 g blood lead.

From EPA's Position on "Health Implications of Airborne Lead", Nov/1973.

TABLE VII-2

Urban-Suburban Blood Lead Comparisons
In Adults

Group Studied	Number Studied	% Blood Leads Equal to or Greater than 40 µg/100 g
Urban Females (2)	423	0.7
Suburban Females	556	0
Phiadelphia Males (4)		
Urban	66	4.5
Suburban	23	0
Composite (3)		
Urban	833	2.7*
Suburban	162	0

*Only those above 40 µg/100g.

From EPA's Position on "Health Implications of Airborne Lead", Nov/1973.

TABLE VII-3

Percentages of Children with Abnormally Elevated Blood Leads

City	Years Tested	Number Tested		% Blood Leads Equal to or Greater than 40 µg/100 g
Baltimore (10)	1968	655		25.3
	1969	746		27.9
	1970	939		31.5
Chicago (10)	1967-70	120,000		20.0
New Haven (10)	1969-70	1,897		29.8
Newark (10)	1970	594		38.9
New York (10)	1969	2,648		45.5
	1970	84,368		28.7
New York (11)	1971	81,626		20.2
Philadelphia (10)	1970	3,496		34.0
Washington (10)	1970	808	(all ages)	5.8
	1970	1,152	(2 years)	22.0
Many Cities (12)	1971	2,309		9.1
Aurora, Ill. (13,14)	1971	449		24.3
Springfield, Ill. (13,14)	1971	670		30.1
Peoria, Ill. (13,14)	1971	387		31.3
E. St. Louis, Ill. (13,14)	1971	376		24.7
Decatur, Ill. (13,14)	1971	793		12.2
Joliet, Ill. (13,14)	1971	383		24.3
Rock Island, Ill. (13,14)	1971	285		21.1
E. Moline, Ill. (13,14)	1971	298		11.4
Robbins, Ill. (13,14)	1971	103		12.6
Harvey, Ill. (13,14)	1971	226		16.4
Carbondale, Ill. (13,14)	1971	264		17.0
Norfolk, Va. (13)	1971	1,225		22.7
New Haven, Conn. (13)	NA	1,339		23.7
Washington, D. C. (13)	1971	1,821		39.2
Rockford, Ill. (13,14)	NA	1,200		19.5

From EPA's Position on "Health Implications of Airborne Lead", Nov/1973

"Lead from all these sources should be reduced to the degree possible."

The E.P.A. document goes on to cite automotive generated lead as the single most important remaining source of lead entering the environment and conclude that lead in gasoline should be reduced.

The E.P.A. has also set emission standards for lead processing operations requiring the use of fabric filters on all emissions > 0.022 grains/dry standard cubic foot.

4.6 Ontario Standards Criteria and Objectives for Airborne Lead

4.6.1 Suspended Lead in Air

In 1968 Ontario's Air Management Branch set a criteria for airborne lead of 15 ug/m^3/24 hours and 10 ug/m^3/30 days.

The air quality criteria were based on the Industrial Occupational Threshold limit value of 150 ug/m^3/8 hours this being the generally accepted procedure when direct data linking exposure and environmental health were unavailable.

In order to meet the 15 ug/m^3/24 hours objective, a design standard of 20 ug/m^3/30 minute was set. This design standard was used to assess new and existing sources of lead emissions and was a standard determining by use of the Pasqiull Gifford Diffusion Equation the allowable emission from a source if the impingement concentration at the nearest receptor was to remain below 20 ug/m^3 for a 30 minute average.

If the 30 minute standard wasmet, the ambient air quality criterion of 15 ug/m^3/24 hours average would readily be met.

As new data on the relationship of low level lead exposure and human health were reported; in late 1972 the Ministry of the Environment using the data of Kehoe & Goldsmith & Hexter proposed a new air quality criterion of 5 ug/m^3/24 hours average with an accompanying design standard of 10 ug/m^3/30 minutes average.

The basis of the 5 ug/m^3 criteria was:

1. Assumption of 300 ug lead intake from diet (10% absorption)
2. Assumption of respiration of 20m^3/day of air (30% absorption of Lead
3. Limiting total daily intake of lead to less than 60 ug/day

Recently in recognition of the long term effects of low level exposure an additional criterion of 2 ug/m^3/30 days geometric mean has been proposed in line with other agencies such as California.

4.6.2 Lead in Dustfall

In recognition of the desirability of limiting lead contamination of soil and dust by settleable particles containing lead with the resultant availability of contaminated material for inadvertent ingestion by humans particularly children and in recognition of the fugitive dust emissions associated with secondary lead smelters and battery plants the Ministry of the Environment has suggested a desirable guideline for lead in dustfall of 0.3 tons/mile^2/30 days (0.1 gram/m^2/30 days).

This guideline is to be used as a measure of the acceptability of lead in dustfall an area but is not a standard or related to a standard in any way.

The bases of the suggested desirable guideline for lead in dustfall are:

1. Limiting soil contamination rates to the point that it will require at least 20 years to exceed the maximum desirable level of 600 ppm starting with soil at 300 ppm lead.

2. Limiting more than a 3-fold increase above normal urban levels of lead in dustfall.

3, Limiting the lead content of dustfall to less than 2% by weight (the criteria for total dustfall is 15 tons/mile^2 /30 days).

As more data on ingestion of dust, dirt and soil become available the suggested desirable objective may have to be lowered. There is already an increasing awareness that lead in soil dirt and dust contaminated by industrial and automotive emissions may be an important cause of human lead absorption.

4.7 Review of Air Quality Standards & Criteria & Objectives for Lead

Table 4.7-1 presents data on current standards and criteria gathered from the literature and from private communications with Air Pollution Control Agencies.

TABLE 4.7-1 Current Air Quality Standards Criteria & Objectives for Airborne Lead

Agency	Standard & Averaging Time (or Criterion)			Remarks
	30 min.	24 hours	30 days	
Montana State	-	-	5 ug/m^3	1970
Pennsylvania State	-	-	5 ug/m^3	1970
U.S.S.R.	-	0.7 ug/m^3	-	1970 Lead
U.S.S.R.	-	1.7 ug/m^3	-	1970 Pbs as lead
Czechoslovakia	-	0.7 ug/m^3	-	
U.S.A.Ind.Hygiene Ass.	-	-	10 ug/m^3	suggested criterion
U.S. E.P.A.	-	-	2 ug/m^3)	proposed June 1973 never promulgated
	-	5 ug/m^3	-)	but basis of gasoline phase out regulations
California State	-	-	1.5 ug/m^3	quoted as standard
New Mexico	-	-	5 ug/m^3	proposed standard
Manitoba, Canada	20 ug/m^3	-	-	proposed standard
Ontario, Canada	20 ug/m^3	15 ug/m^3	5 ug/m^3	1968 standard & criteria
	10 ug/m^3	5 ug/m^3	2 ug/m^3	proposed standard & criteria (1972)
Environment Canada	-	5 ug/m^3	-	suggested objective (1974)
VDI Kommission Reinhaltung der Luft (Ger)	-	1-3 ug/m^3	-	suggested criterion Nov73 under discussion
City of Toronto Board of Health		5 ug/m^3	2 ug/m^3	1974 criteria

TABLE 4.7-2 Specific Source Emission Standards

Type of Source	Agency	Emission Standard
Secondary Lead Smelter	EPA	0.022 grains/dry standard cu.ft.
Secondary Lead Smelter	UK MOE	0.05 grains/scf $<$ 10,000 scfm
		0.01 grains/scf 10,000-140,000 scfm
		0.005 grains/scf $>$ 140,000 scfm
Secondary Lead Smelter	Environment Canada	
1. Furnaces		0.02 grains/scfm
2. Materials Handling		0.01 grains/scfm
3. Storage		0 grains/scfm

It can be seen that the proposed Ontario Standards for airborne lead are well in line with other agencies and in addition the desirable objectives for lead in dustfall and in soil are useful indicators of contaminated areas.

The City of Toronto Board of Health has retained consultants from the University of Toronto and Ontario Research Foundation who endorsed the levels proposed by Ontario's Environment Ministry.

There are some who are advocating more stringent standards such as 1.5 $ug/m^3/24$ hours for airborne lead, 0.1 $tons/mile^2/30$ days for lead in dustfall and 200 ppm in

soil. These levels are however commonly exceeded in most downtown and some suburban residential areas even those remote from major streets and highways and are more nearly those found in rural areas. There is at this time no evidence in Toronto of undue lead absorption by a significant proportion of the general population remote from highway and industrial lead sources which would warrant adoption of more stringent standards.

4.8 Ambient Air Monitoring Practices for Lead

Suspended particulate matter in the ambient air is measured by means of hi volume samplers which are operated for 24-hour periods during which time approximately 2000 cubic metres of air are pumped through standard preweighed filters. Particles within the size range of 0.1 - 100 un may be collected.

The use of cascade impactor heads such as the Andersen head with the hi-volume sampler enables fractionation of the particles into 5 different size ranges.

0.1	-	1.1	µm	
1.1	-	2.0	µm	
2	-	3.3	µm	50% cutoff based on latex spheres
3.3	-	7	µm	of unit density
> 7 µm				

At the end of the sampling period the sampler shuts off automatically and the filters are removed and delivered to the laboratory in marked containers.

The filters are weighed to determine the amount of suspended particulate matter deposited which when divided by the air volume gives the ambient air level in micrograms per cubic metre of air (ug/m^3).

Dustfall comprises the larger particles which settle out of the air due to the influence of gravity and is measured by exposing open cylinders of specified dimensions for a period of 30 days. The total deposit in the cylinder is weighed and comprises the materials which have dropped into the container (dry deposit) as well as those which have been scavenged by precipitation which has fallen into the container during the month.

In practice the standard unit of measurement for dustfall is tons per square mile per 30 days, which can be converted into grams per square metre per 30 days by multiplication by 0.285.

Lead in suspended particualte and dustfall is determined by taking a portion of the filter or dustfall sample and analysing by atomic absorption spectroscopy.

References to Section 4

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4. Goldsmith, J.R., Hexter, A.C., Respiratory Exposure to Lead Epidemiological and Experimental Dose - Response Relationship Science, 158, 132-143, 1967.

5. Goldsmith, J.R., Epidemiological Bases for Possible Air Quality Criteria for Lead. Journal of Air Pollution Control Association, 19, No. 19, 714, September, 1969.

6. Proposed Revisions of, and Addition to, the Ambient Air Quality Standards. State of California Air Resources Board. October 21, 1970.

7. Review of Air Quality Standards for Lead, Report to Dr. Moss, Medical Officer of Health, December, 1973, by the Air Management Branch, Ministry of the Environment.

8. Draft of Proposed Regulations under the Clean Air Act for inclusion in Part I of the Canada Gazette. Secondary Lead Smelter Emission Standard Regulations, 1974.

9. Brief to Manitoba Clean Environment Commission, June 4, 1974. Internal Document, Environment Canada.

5. LEGAL OPTIONS UNDER CURRENT LEGISLATION

5.1 Information

Section 84(1) of The Environmental Protection Act (E.P.A.) is the main provision enabling the gathering of information. The most recent amendment to this Section took effect April 1, 1974. In its present form the Section reads as follows:

> *"For the purpose of the administration of this Act and the regulations, a provincial officer may, from time to time and upon production of his designation, enter at any reasonable time any building, structure, machine, vehicle, land, water or air and make or require to be made such surveys, examinations, investigations, tests and inquiries, including examinations of books, records and documents, as he considers necessary, and may make, take and remove or may require to be made, taken or removed samples, copies or extracts."*

Subsection 3 of Section 84 provides that every person responsible for a source of contaminant shall furnish such information as a provincial officer requires for the purposes of this Act or the regulations.

5.2 Installation of Abatement Equipment

Pollution abatement equipment may be installed and measures taken on a voluntary basis by a company. This could be achieved simply by an understanding reached as to the equipment to be installed and the dates for installation.

Alternatively, the voluntary abatement measures may be formalized by the submission by a company of a program to prevent or to reduce and control the emission of a contaminant. This is provided for in Sections 10 and 11 of The E.P.A.

The Director then has a discretion to issue or not to issue a program approval to the company who submitted the program which sets out, among other things, "the details of the program". It should be noted, however, failure to comply with a provision of the program approval does not constitute an offence under the Act and yet full compliance with the program approval results in the protection against prosecution as provided in Section 102 set out below.

Control Orders

A power to issue control orders is provided in Section 6 of the Act which reads as follows:

> *"When the report of a provincial officer, filed as provided by Section 83, contains a finding that a contaminant added to, emitted or discharged into any part of the natural environment by any person or from any source of contaminant exceeds the maximum permissible amount, concentration or level prescribed by the regulations, contravenes Section 14 or is a contaminant the use of which is prohibited by the regulations, the Director may issue a control order directed to the person responsible therefor."*

A further power to issue control orders is provided by Section 12 which reads as follows:

"Notwithstanding the issue of a program approval, when the Director is of the opinion, based upon reasonable and probable grounds, that it is necessary or advisable for the protection or conservation of the natural environment, the prevention or control of an immediate danger to human life, the health of any persons or to property, the Director may issue a stop order or a control order directed to the person responsible."

It will be noted that Section 12 confers a much broader discretionary power on the Director. Although there has been no judicial determination on this point, it is likely that Section 12 also applies in situations where no program approval has been issued.

Where the Director is authorized, either under Section 6 or Section 12 to issue a control order, the content of the order as to what the company is directed to do must stay within the scope of Section 70 which reads as follows:

"The Director may, where he is authorized by this Act to issue an order known as a "control order", order the person to whom it is directed to do any one or more of the following, namely,

(a) to limit or control the rate of addition, emission or discharge of the contaminant into the natural environment in accordance with the directions set out in the order;

(b) to stop the addition, emission or discharge of the contaminant into the natural environment,

(i) permanently,

(ii) for a specified period, or

(iii) in the circumstances set out in the order;

(c) to comply with any directions set out in the order relating to the manner in which the contaminant may be added, emitted or discharged into the natural environment;

(d) to comply with any directions set out in the order relating to the procedures to be followed in the control or elimination of the addition, emission or discharge of the contaminant into the natural environment; and

(e) *to install, replace or alter any equipment or thing designed to control or eliminate the addition, emission or discharge of the contaminant into the natural environment."*

The scope of the above provision is fairly wide and includes a power to stop permanently or for a specific period the emission of a contaminant into the natural environment. It also includes a power to order the installation of equipment designed to control or eliminate the emission of a contaminant.

The failure to comply with an order constitutes an offence under the Act. This sanction is, however, meaningful only if it can be readily determined when the order has not been complied with. In the case of an order to install abatement equipment, therefore, the kind of equipment to be installed or procedures to be followed must be set out with sufficient precision so any failure to comply can be readily established.

A control order is appealable within fifteen days after service to the Environmental Appeal Board. It is provided by Section 79(2) of the Act that the order shall not be enforced until final disposition of an appeal, if any, or until the time for taking an appeal against the order has passed. It is likely that final disposition includes appeal from the decision of the Environmental Appeal Board to the courts. It is possible, therefore, for some time to elapse before a control order can be enforced. When an appeal is taken in this way, the Environmental Appeal Board has the authority to confirm, alter or revoke the order.

A further consequence of a control order should also be noted. Section 102(2) of the Act provides as follows:

> *"Notwithstanding Subsection 1, a person to whom an order or program approval of the Minister or the Director is directed who complies fully with the order or approval shall not be prosecuted for or convicted of an offence in respect of the matter or matters dealt with in the order or approval that occurs during the period within which the order or program approval is applicable."*

Public Health Act

Certain provisions of The Public Health Act are also of interest with respect to requiring installation of abatement equipment. The term "nuisance" is defined broadly to mean "any condition existing in a locality that is or may become injurious or dangerous to health ....". The term also comprises a number of special categories including "any work, manufactory, trade or business so situated as to be injurious or dangerous to health".

Section 92(1) provides:

> *"Wherever the local board or medical officer of health is satisfied of the existence of a nuisance, the medical officer of health shall serve a notice on the person by whose act, default or sufferance the nuisance arises or continues, or, if such person cannot be found, on the owner or occupier of the premises on which the nuisance exists or from which it arises, requiring him to abate it within a time to be specified in the notice and to execute such works and do such things as may be necessary for that purpose."*

However, Section 96(1) provides that where "such removal or abatement" involves the loss or destruction of property to the value of $2,000 or more,

an order of a judge of the Supreme Court is required before the removal or abatement can be enforced.

5.3 Removal of Contaminated Soil

In this section we deal with the options available to deal with the problem of residual lead on private property in the area of secondary lead smelters. Section 17 of The Environmental Protection Act reads as follows:

> *"Where any person causes or permits the deposit, addition, emission or discharge into the natural environment of a contaminant that injures or damages land, water, property or plant life, the Minister, where he is of the opinion that it is in the public interest so to do, may order such person to do all things and take all steps necessary to repair the injury or damage."*

The section is supported by Section 99 which provides:

> *"Where the Minister or the Director has authority to order or require that any matter or thing be done, the Minister may order that, in default of its being done by the person ordered or required to do it, such matter or thing shall be done at the expense of such person, and the Minister may recover the cost of doing it, with costs, by action in a court of competent jurisdiction as a debt due to the Crown by such person."*

It is clear that it is a condition precedent of the application of Section 17 that a company must have caused or permitted the deposit or emission of contaminants that injures.....land. It seems clear that a high concentration of residual lead in soil does injury to land by affecting some of its uses. If, however, some of the residual lead came from other sources or was deposited prior to the coming into force of the Act (August 11, 1971), it is not possible

to say in advance how the courts would apply the section to such circumstances.

Section 95 of The Public Health Act should also be referred to this context. Sections 95(1) and 95(2) provide:

"95(1) *Where the owner or occupier of any premises in which a nuisance exists fails, after due notice, to abate it, the medical officer of health or public health inspector may enter the premises and take such steps as may be necessary to abate it.*

(2) *All reasonable costs and expenses incurred in abating a nuisance shall be deemed to be money paid for the use and at the request of the person by whose act, default or sufferance the nuisance was caused, and are recoverable from both the owner and the occupier for the time being of the premises."*

It appears, therefore, that if the existence of residual lead in the ground (as distinct from current emissions from a plant) is a separate nuisance, the M.O.H. may "take such steps as may be necessary to abate it". He also has a right of entry for this purpose. It may be, however, that the courts would not interpret Section 95(2) so as to allow the costs to be recovered from anyone other than the owner or occupier of the premises in which the nuisance exists.

5.4 Suspension of Plant Operations

A power to issue stop orders is provided in Section 7 of The E.P.A. which reads as follows:

"When the Director, upon reasonable and probable grounds, is of the opinion that a source of contaminant is adding to, emitting

or discharging into the natural environment any contaminant that constitutes, or the amount, concentration or level of which constitutes, an immediate danger to human life, the health of any persons, or to property, the Director may issue a stop order directed to the person responsible for the source of contaminant."

A further power to issue stop orders is provided by Section 12, quoted above under "Control Orders". It may be seen that Section 12 confers a much broader discretionary power on the Director. As with control orders, it is likely that Section 12 also applies in situations where no program approval has been issued. Section 12 may be exercised where the Director is of the opinion, based on reasonable and probable grounds, that it is necessary or advisable for "the prevention or control of an immediate danger to.....the health of any persons". Although the "immediate danger" concept is employed, the concept of an action to prevent such immediate danger is used. When a stop order may be issued, it must keep within the confines of Section 74 which provides:

"The Director may, where he is authorized by this Act to issue an order known as a "stop order", order the person to whom it is directed to immediately stop or cause the source of contaminant to stop adding to, emitting or discharging into the natural environment any contaminant either permanently, or for a specific period of time."

A stop order takes effect immediately on service. It may, however, be appealed to the Environmental Appeal Board which has the authority to confirm, alter or revoke the order. It may also be challenged in the Supreme Court of Ontario pursuant to The Judicial Review Procedure Act.

By an amendment to The Public Health Act which came into force on July 3, 1974, a new Section 87 was inserted which provides expressly for closing of premises

in the following terms:

"87(1) *The medical officer of health of a municipality or any inspector or other person in the employ of the local board acting under his instructions may enter any premises in the municipality, and an inspector appointed under Section 2a may enter any premises, at all reasonable times and inspect and examine the premises for the purpose of carrying out this Act and may take such action as he considers necessary for carrying it out including, where he finds that a condition exists in or about the premises that,*

(a) is dangerous or is likely to become dangerous to health or safety; or

(b) hinders or is likely to hinder the prevention, mitigation or suppression of disease,

the making of an order that the premises be closed and remain closed until the condition no longer exists in or about the premises, and any person in charge of the premises for the time being shall render such assistance as is necessary to make such entry, inspection and examination."

5.5 Planning

Section 35(1) of The Planning Act permits municipalities to pass by-laws for prohibiting the use of land, for or except for such purposes as may be set out in the by-law. Use of this provision to deal with incompatible uses is, however, made difficult by Section 35(7) of the Act which provides:

"No by-law passed under this Section applies,

(a) to prevent the use of any land, building or structure for any purpose prohibited by the by-law if such land, building or structure was lawfully used for such purpose on the day of the passing of the by-law, so long as it continues to be used for that purpose."

6. ENVIRONMENTAL LEAD LEVELS NEAR LEAD PROCESSING PLANTS

6.1 CANADA METAL COMPANY

6.1.1 Review of Plant Operations

The Canada Metal Company, Limited manufactures lead and lead alloys for solder, and lead oxide for use in batteries and as paint and ink pigments. The lead is derived from the melting of scrap lead battery plates and other forms of lead oxide in a blast furnace. Various sized pots are used for melting and alloying lead with various other metals.

The lead oxide is produced by melting lead in a pot furnace and subsequently converting this molten lead chemically into lead oxides in oxidizing furnaces.

Smelting Operations (Process Flow Sheet No. 6.1.a)

Scrap lead materials are received by truck and rail car from various parts of Canada and the U.S.A., unloaded and stored in a covered enclosure for subsequent processing in a lead blast furnace. Under unusual operating conditions, it occasionally becomes necessary to store material under plastic tarpaulins on a concrete pad.

The lead blast furnace is constructed similarly to those used in ferrous smelting. The charge materials are taken by front end loader from the storage areas, dumped into a skip hoist and fed through the charging door into the blast furnace.

A typical charge to the furnace is composed of scrap lead battery plates, lead drosses and other forms of lead oxide, coke, limestone, scrap iron and rerun slag. The drosses are obtained from refining processes in the pot furnaces and the rerun slag results from previous blast furnace runs.

As the level of molten material rises, slag is tapped at intervals and poured into a slag crucible located at the side of the furnace. Molten lead flows from the furnace at a fairly continuous rate and the cast "hard" lead ingots formed are stored for further processing.

Emissions (Table 6.1.1)

Dust and fume emissions from the skip hoist and tap areas of the blast furnace are exhausted through an approved bag filter before the cleaned gases are emitted to the atmosphere via a 22 ft. high, 1.5 ft. diameter vent. The flue gases from the blast furnace containing particulate, sulphur dioxide and nitrogen oxides are passed through an afterburner and sequentially through a fallout chamber, U tube cooler and a baghouse before the cleaned gases are emitted to the atmosphere via a 152-ft. high, 6-ft. diameter vent.

In addition, fugitive dust emission sources result from vehicular traffic and unloading and handling of scrap lead. Emission data on these sources is indeterminate. However, emissions from thse sources are now minimized by good housekeeping practices.

Refining and Alloying Operations (Process Flow Sheet No. 6.1.b)

Various sized pot type furnaces fired by natural gas are used for remelting, alloying and refining processes. In this operation, lead may be alloyed with arsenic, tin, antimony, silver or cadmium. The alloying materials charged are in ingot form and may be obtained from other manufacturers. The process time varies from a few hours for the small pots to over 24 hours for the larger pots.

Emissions

The melting, alloying and refining pots and a silver pot are hooded and the fumes containing lead and alloying materials are collected in an approved bag filter before the cleaned gases are emitted to the atmosphere via the 152-ft. stack.

Lead Oxide Operations (Process Flow Sheet 6.1.c)

Lead oxide is manufactured from high purity lead by the Barton Process. In this process, refined lead ingots are melted in a small pot furnace, then the molten lead is run by gravity into kettles equipped with rotating paddles. Air is drawn through the kettles by fans located on the air outlet side of a baghouse. The lead oxide thus formed is conveyed to a collection chamber for storage and air from the chamber is drawn to the bag filter. The recovered lead oxide is then transferred by screw conveyor from the bag filter to the collection chamber for storage.

The oxide may be further processed by calcining it at a specified temperature in direct fired natural gas furnaces. The products formed are transferred by means of enclosed conveyors to storage hoppers.

From the storage hoppers, the stored lead oxide is fed by screw conveyors through milling machines then bagging machines for shipment.

Emissions (Table 6.1.1)

Dust and fume emissions from the pot furnaces, kettles and the collection chamber are ducted to bag filters and the cleaned gases exhausted to atmosphere via 60-ft.-high stacks.

Any dust generated from the storage hoppers following calcining is collected in a bag filter and the cleaned gases exhausted to the atmosphere via 60-ft.-high stacks. The flue gases from the direct fired furnaces containing combustion products and lead oxide are cleaned by approved baghouses before being emitted to atmosphere via 60-ft.-high stacks.

Roto-Cast Division (Process Flow Sheet No. 6.1.d)

The roto-Cast Division of Canada Metal Company alloys copper with tin or zinc to make bronze castings. Operations in the plant include continuous casting and centrifugal casting processes which utilize various types of rotary and tilt furnaces and a pit furnace for remelting, alloying and casting processes.

For larger castings and continuous casting, tilting furnaces are used in conjunction with rotary holding furnaces used for pouring operations. For small castings, the pit furnace is utilized. In addition, there are rotary furnaces utilized for melting metal ingot and turnings from the machining and cutting operations. Molten metal

is poured into ladels and transferred by mono-rail crane to electric, horizontal holding furnaces prior to centrifugal casting.

Emissions (Table 6.1.1)

Throughout the plant, hoods are positioned over the various furnaces to exhaust fume emissions containing lead, tin, zinc and copper oxides produced during melting and pouring of the metal.

The combined emissions are exhausted to the atmosphere through the main 152 ft. high stack used by Canada Metal Company.

6.1.2 Review of Abatement Activities

A detailed review of the abatement activities since 1965 is contained in the Interim Report of Lead in the Environment in the Vicinity of Secondary Lead Smelters in Metropolitan Toronto, prepared by the Ontario Ministry of the Environment.

In review, since 1969, to the present time, the company has been required by the Ministry to undertake modifications to plant operations and equipment in order to reduce emissions and attain compliance with the Act and Regulations including the following:

a) installation of ductwork to an existing baghouse to control emissions from the lead melting kettle in the lead oxide plant.

b) installation of ductwork to an existing baghouse to control emissions from the skip hoist and tap areas of the blast furnace.

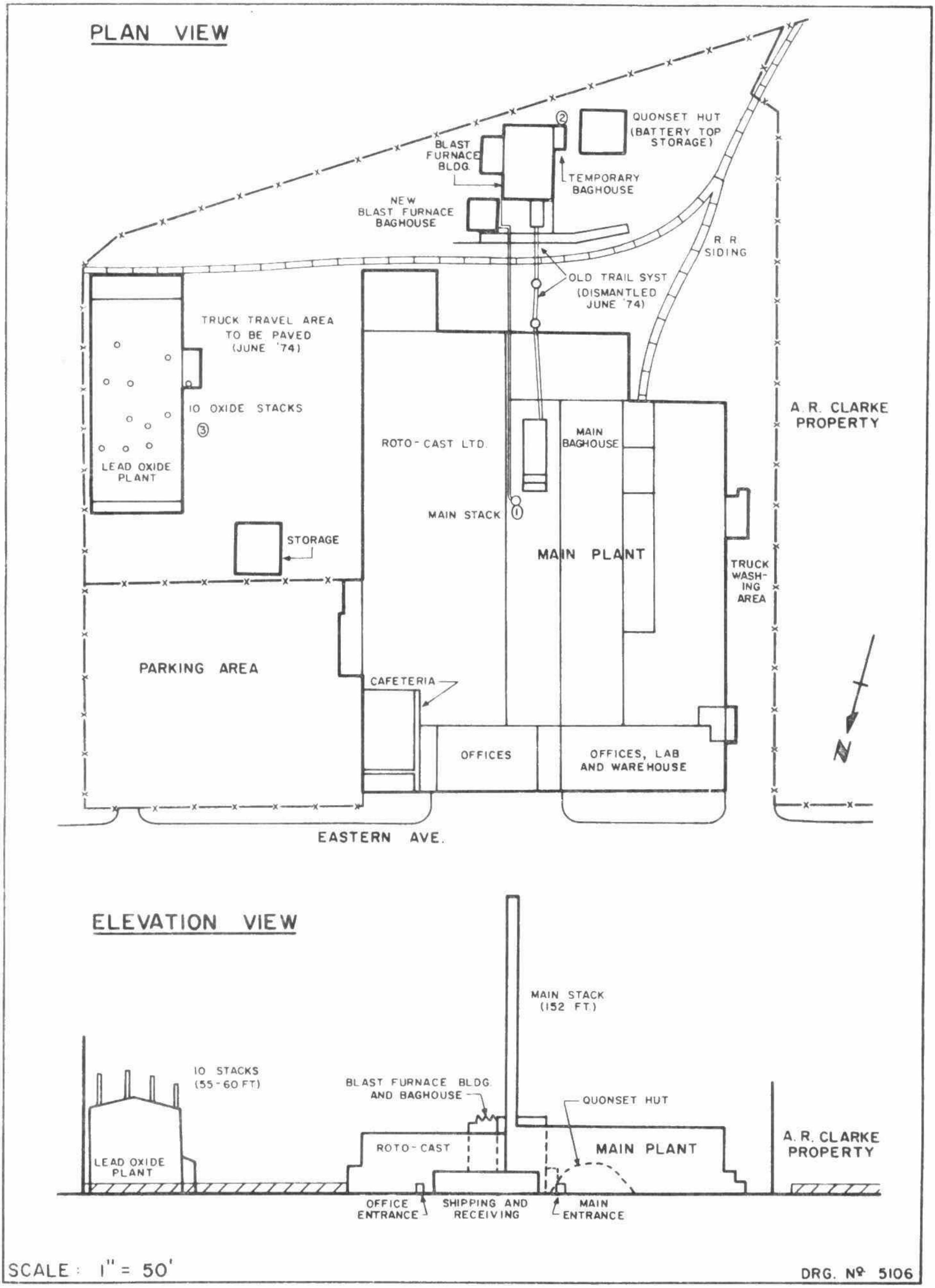


FIGURE - PLAN AND ELEVATION VIEW FOR CANADA METAL CO.

TABLE 6.1.1 - 1

SUMMARY OF EMISSION DATA

CANADA METAL CO. LTD.

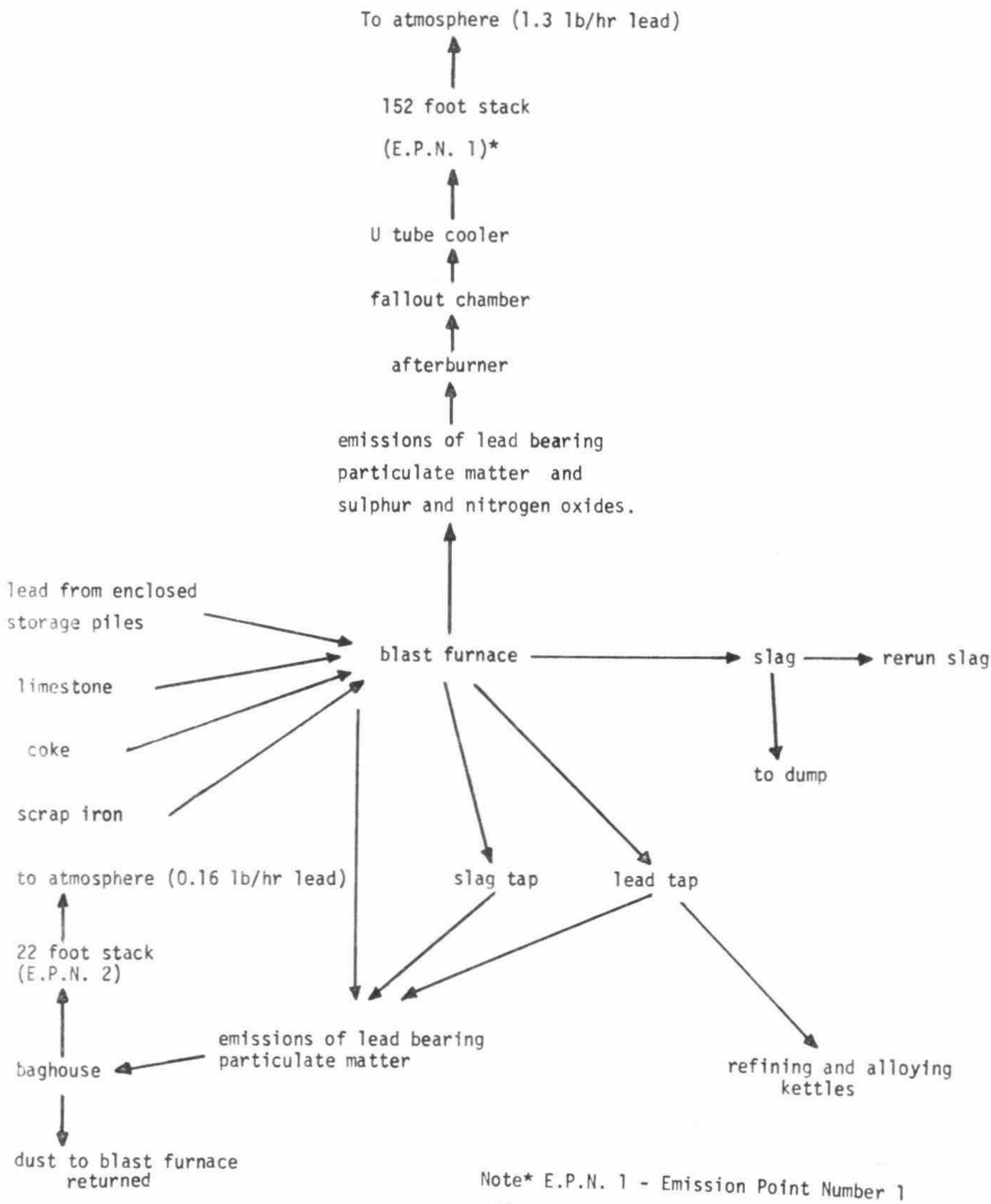
ROTO-CAST LTD.

SOURCE	LEAD EMISSION RATE, LB/HR	
	JANUARY 1968	JUNE 1974
CANADA METAL CO. LTD.		
Blast Furnace	4.0	1.3
Melting & Alloying	4.8	1.3
Slag Tap	1.0	---
*Reverb. Furnace	2.6	----
Skip Hoist		
Tap Areas	----	0.16
Lead Oxide Plant	1.5	0.5
TOTAL LEAD	13.9	3.26
Fugitive Emissions from yard operations and building ventilation	Indeterminate	
ROTO-CAST LTD.	11.2	4.3
Total Lead for Plant	25.1	7.56

* Removed from service in 1971

PROCESS FLOW SHEET NO. 4.1.a

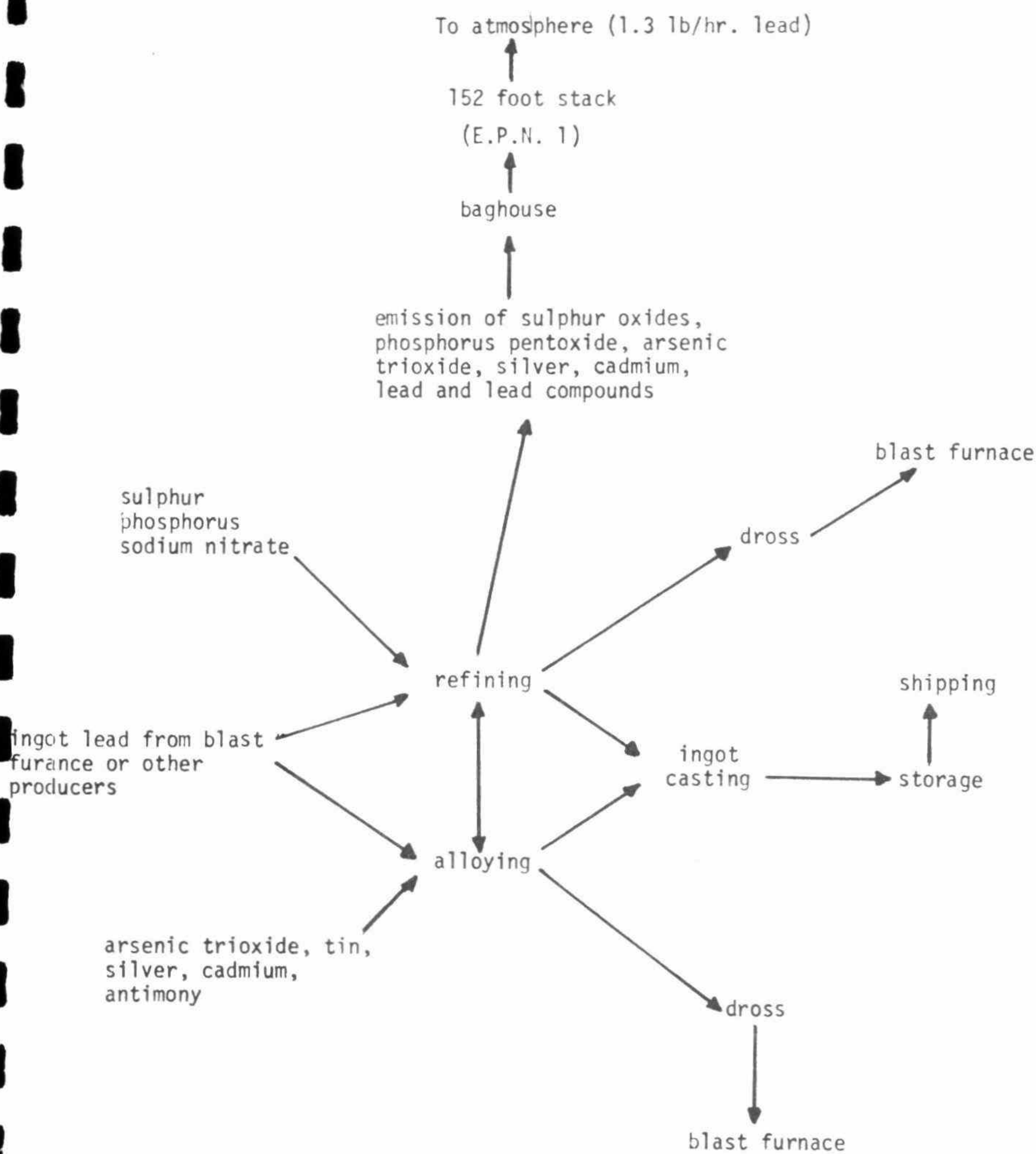
SMELTING OPERATIONS



Note* E.P.N. 1 - Emission Point Number 1

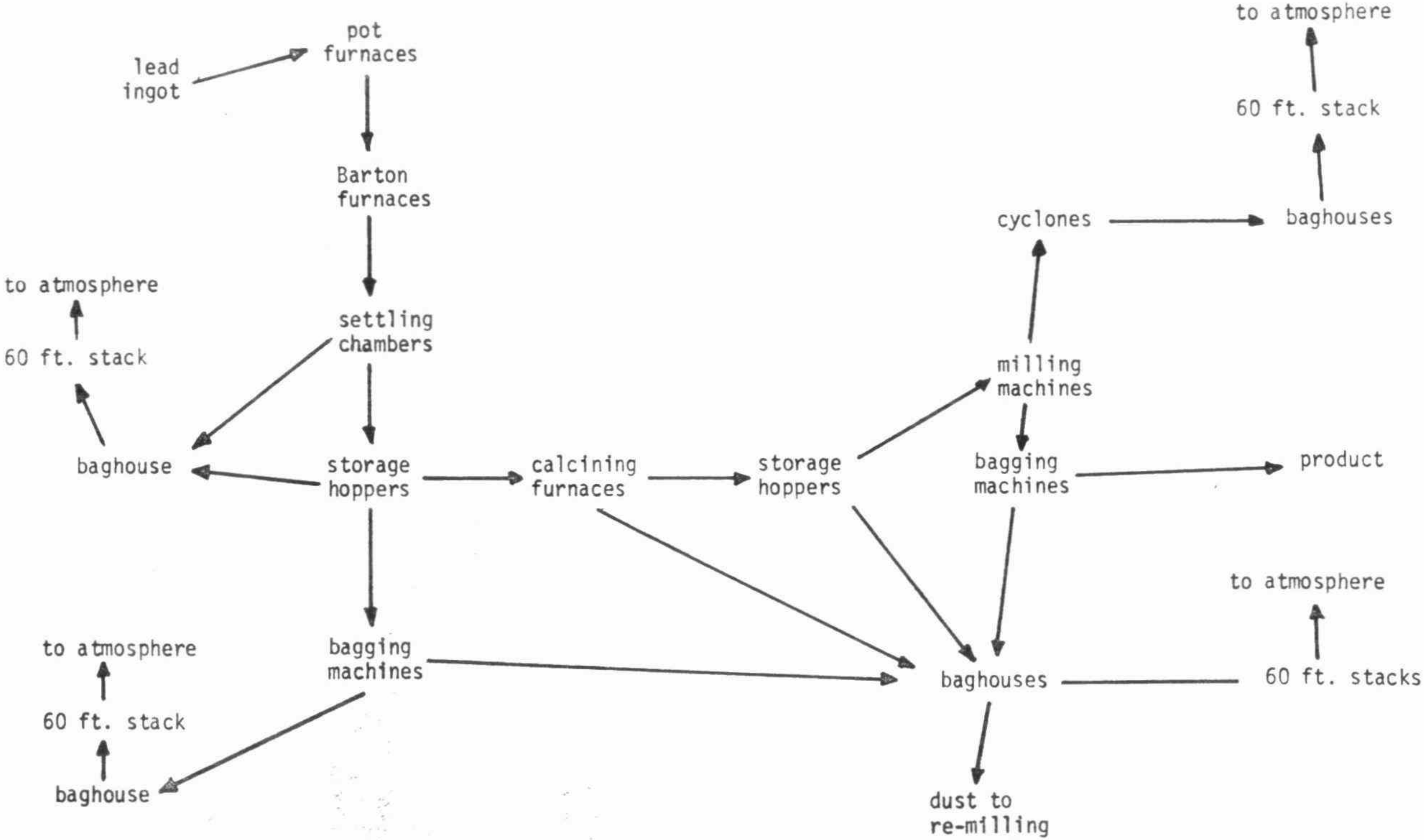
PROCESS FLOW SHEET NO. 4

REFINING AND ALLOYING OPERATIONS



PROCESS FLOW SHEET NO. 4.1.c

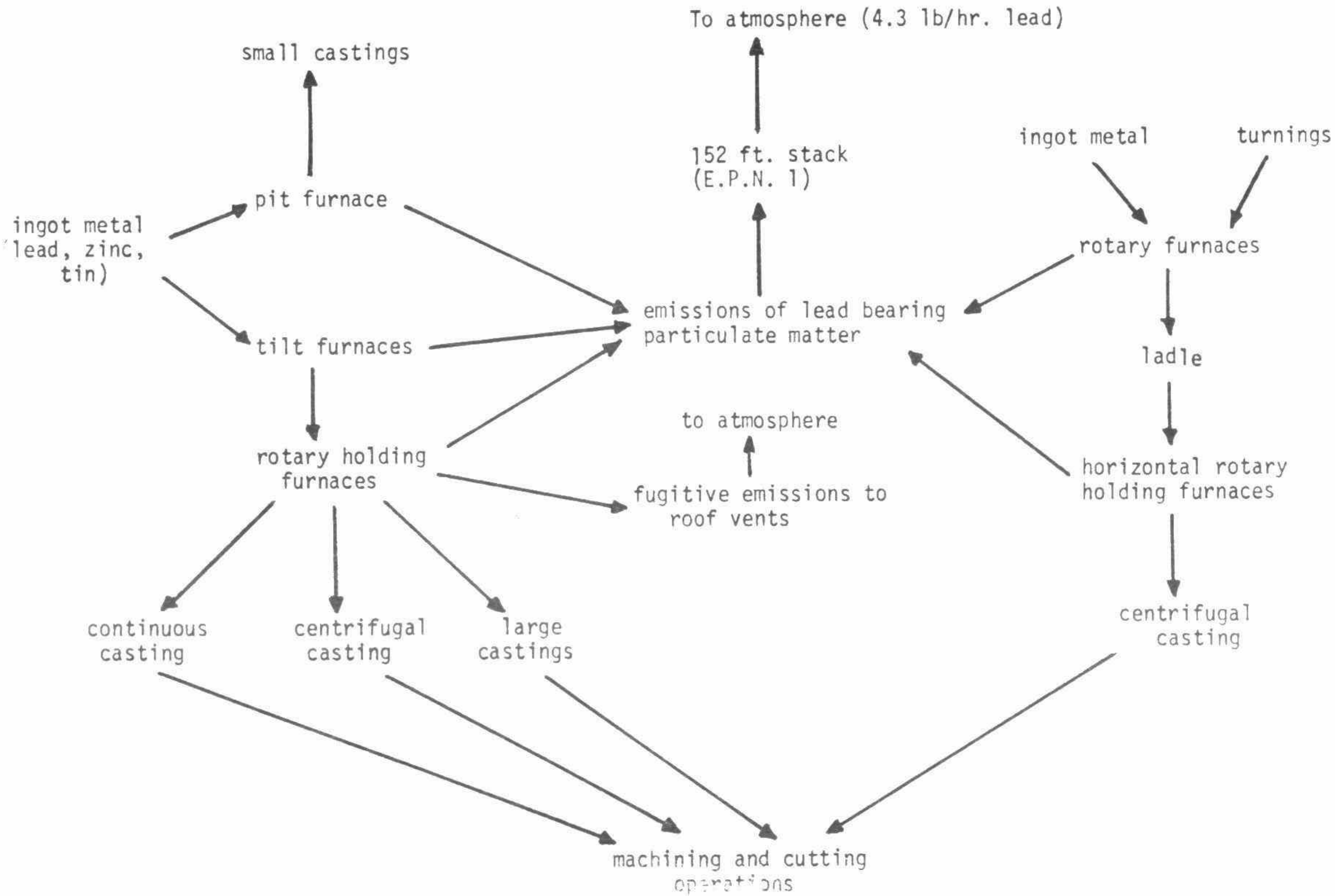
LEAD OXIDE OPERATIONS



NOTE; Combined emission from Lead Oxide Operations to atmosphere 0.5 lb/hr. lead

PROCESS FLOW SHEET NO. 4.1.d

ROTO-CAST DIVISION



c) installation of a new baghouse to control emissions from the blast furnace.

d) installation and revision of ductwork to main baghouse in order to control emissions from the lead melting, alloying and refining furnaces.

e) installation of a new baghouse to control emissions from the calcining furnaces in the lead oxide plant.

f) the erection of a roofed enclosure over working battery scrap piles.

g) the operation of a tire washing area to serve all trucks leaving the premises.

h) complete paving of in-plant traffic routes and maintenance of regular sweeping in these areas.

i) segregation of traffic routes for in-plant vehicles from vehicles that move off the property.

In addition to the measures outlined previous, the Company has advised the Ministry of the Environment that further abatement action is being undertaken including the following:

1) hard surface a graveled area to be used for storage of spare melting pots and various pieces of equipment.

2) sod remaining plant areas not hard surfaced.

3) remove the temporary baghouse being used to control emissions from the skip hoist and tap areas of the blast furnace and exhaust these sources to the new blast furnace baghouse.

4) construct a roofed enclosure from the roofed scrap lead enclosure to the blast furnace building to minimize outside transfer of scrap lead materials from storage.

5) purchase a third mechanical sweeper to provide for more effective yard cleaning operations.

6.1.3 Summary of Ambient Lead Levels in Vicinity of Canada Metals

The lead content of the suspended particulate matter and dustfall samples have been obtained for the sampling stations in vicinity of Canada Metals plant at locations shown in the map of Fig. 6.1.3-1.

A summary of the lead data obtained to date in the daily samples of suspended particulate matter are given in Table 6.1.3-I. The lead component of the monthly dustfall measurements are given in Table 6.1.3-II(a) and (b).

At sampling station No. 31058 located in the direction of the prevailing wind from Canada Metal, the lead levels in suspended particulate matter in the past year frequently exceeded the proposed criterion of 5 ug/m^3 as well as the criterion of 15 ug/m^3 . The geometric mean over the period sampled exceeded the longer term criterion of 2 ug/m^3. At Station No. 31065 located to the east of Canada Metal, the data indicated that higher than desirable levels of lead also occurred on a frequent basis. Correlations were obtained to determine whether the concentrations of lead would correlate with the number of hours during the sampling periods that winds were in direction from the plant to the samplers. The analyses carried out for both total suspended particulate matter and the lead components are shown in the graphs of Figures 6.1.3-2 and 6.1.3-3. Significant correlations were obtained between the lead concentrations and the number of hours that were in the direction from the plant property towards the sampling station indicating that the plant was the principle source of the lead concentrations measured at the two locations.

Abatement of emissions of lead by the plant has taken place during the spring of 1974. The effects of the abatement are being reflected by improving air quality levels obtained during the month of April, 1974. The trend in air quality at Station No. 31058 for which data is available since the fall of 1973 is shown in Figures 6.1.3-4 and 6.1.3-5. The upper graphs give the 28-day and 7-day moving averages of concentrations of lead during days in which lead was sampled. The lower graph in the figures gives the moving averages of the number of hours that winds were in the direction of the plant property toward the station. It may be noted that although the wind frequency was lower during the latter spring months, the average lead concentrations were much lower during these months than they were during the fall and early winter months. The maximum concentration of lead in suspended particulate matter measured in April, 1974 was 7.69 ug/m^3 as compared to the maximum during March of 39.93 ug/m^3, and the maximum for the entire period of measurements of 74.40 ug/m^3. Although air quality levels with respect to lead in suspended particulate matter have improved, there are occasional days that concentrations exceed the proposed criterion of 5 ug/m^3.

Dustfall levels in vicinity of Canada Metal obtained during 1974 have in general met Ontario's guideline of 0.30 tons per square mile per 30 days. These measurements were all at distances greater than 250 feet from the property line.

Figure 6.1.3-6 indicates the relationship of the average lead in dustfall levels with distance from the plant. A computation which assumes equal dustfall levels in any direction from the plant indicates a deposit of approximately 5 pounds per day of lead would produce the amount indicated.

The size distribution of the particles were determined by the utilization of particle fractionating Andersen heads on the high volume sampler at Station No. 31058. The particle sizes obeyed a log normal distribution. With high lead loadings and winds from the direction of Canada Metal, there was a general increase in all size ranges with lead concentrated in the large particle sizes. The size distribution during higher than 5 ug/m^3 measurements were found to be very different to that obtained near major traffic arteries. A comparison is given in Figure 6.1.3-7 between the size distribution near the lead plant and that obtained near Highway 401, west of Highway 10, near Queen Elizabeth Highway and Evans Avenue and near Bay Street north of Grosvener Street. When the winds were not from the direction of Canada Metal, the distribution of particle sizes are similar to that near traffic arteries. The differences in distribution imply that the increase in lead levels in each size range during high measurements is due to emissions from the Canada Metal plant.

TABLE 6.1.3-I

CANADA METAL
LEAD LEVELS IN SUSPENDED PARTICULATE MATTER

Station No.	Location Name	Location Description	Period Sampled	No. of Days Sampled	Geom. Mean $\mu g/m^3$	Maximum Conc. $\mu g/m^3$	No. of Days Conc. >5 $\mu g/m^3$	% of Days Conc. >5 $\mu g/m^3$	No. of Days Conc. >15 $\mu g/m^3$	% of Days Conc. >15 $\mu g/m^3$
045A	Bruce Public School	Roof of Main Bldg. 400 ft. North of C.M.	20/1/72 to 6/10/72	99	1.62	18	6	6	1	1
045B	Bruce Public School	Roof of Portable Bldg. 400' N. of C.M.	28/10/73 to 16/4/74	146	0.98	5	0	0	0	0
058	931 Eastern Ave.	50 ft. East of C.M.	15/4/73 to 25/5/74	177	3.87	74	62	35	29	16
064	17 Berkshire	160 ft. N. of C. M.	14/11/73 to 24/5/74	115	1.34	6	3	3	0	0
065	633 Eastern Ave.	250 ft. West of C. M.	9/12/73 to 31/4/74	122	1.72	27	16	13	4	3

TABLE 6.1.3-II(a)

LEAD IN DUSTFALL RESULTS - CANADA METAL LIMITED

TONS PER SQUARE MILE PER MONTH

1 9 7 3

STATION NO.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
31019	0.40	0.48	0.51	0.55	0.45	0.71	0.64	0.43	0.50	0.57	Invalid	0.20	0.49
31059				0.56	0.77	0.73	1.16	0.56	0.19	0.78	0.17	0.14	0.56
31060				0.11	0.12	0.16	0.15	0.19	0.45	0.17	0.07	0.06	0.16
31061				0.09	0.06	0.10	0.13	0.08	0.13	Invalid	0.07	0.05	0.09

TABLE 6.1.3-II(b)

LEAD IN DUSTFALL RESULTS - CANADA METAL LIMITED

TONS PER SQUARE MILE PER MONTH

1974

STATION NO.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
31019	0.26*	0.21		.25	.18							
31059	0.16*	0.28	.25	.17	.18							
31060	0.04*	0.08	.07	.20	.09							
31061	0.03*	0.07	.07	.06	Invalid							

* INSOLUBLE lead only

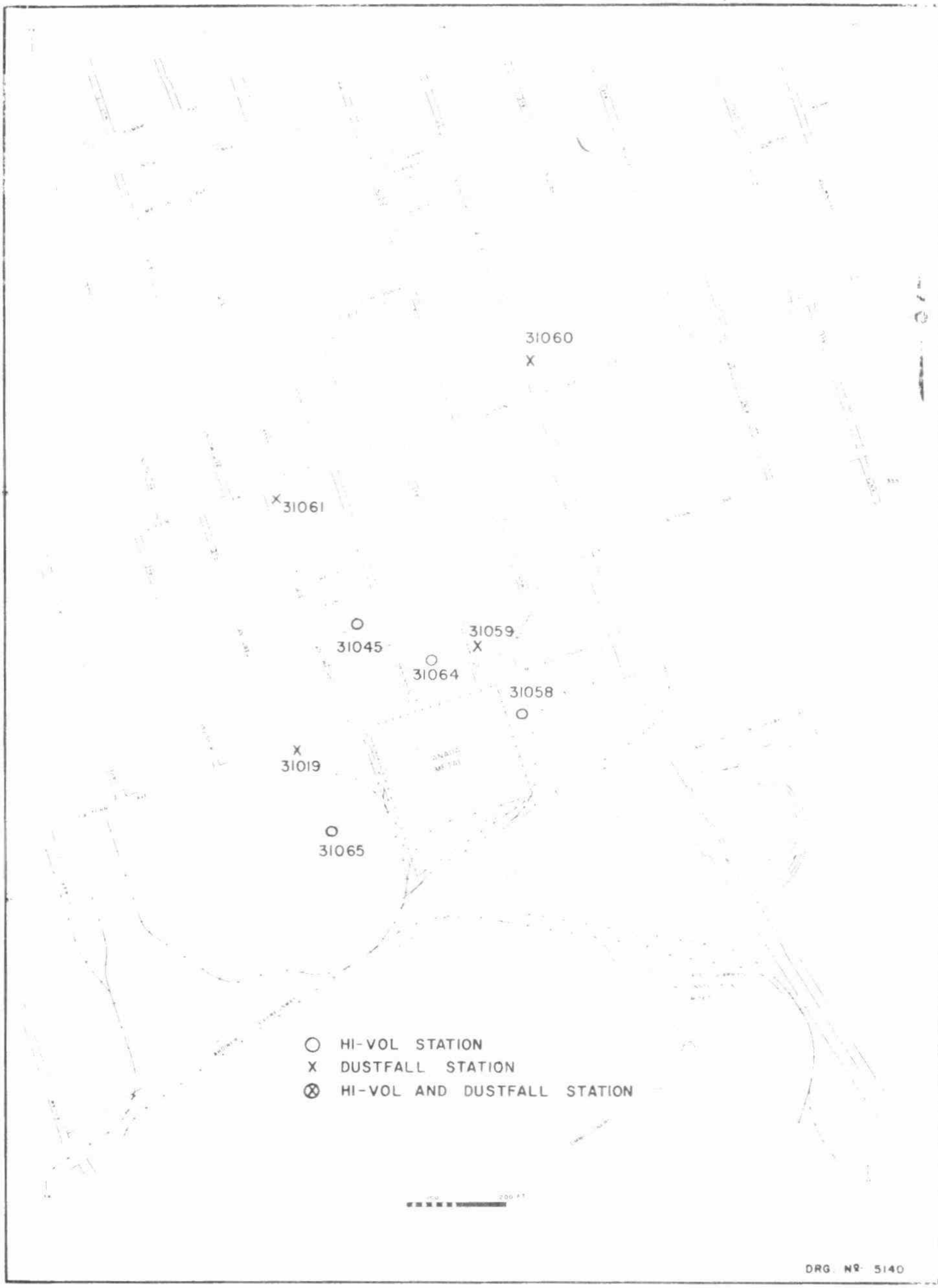
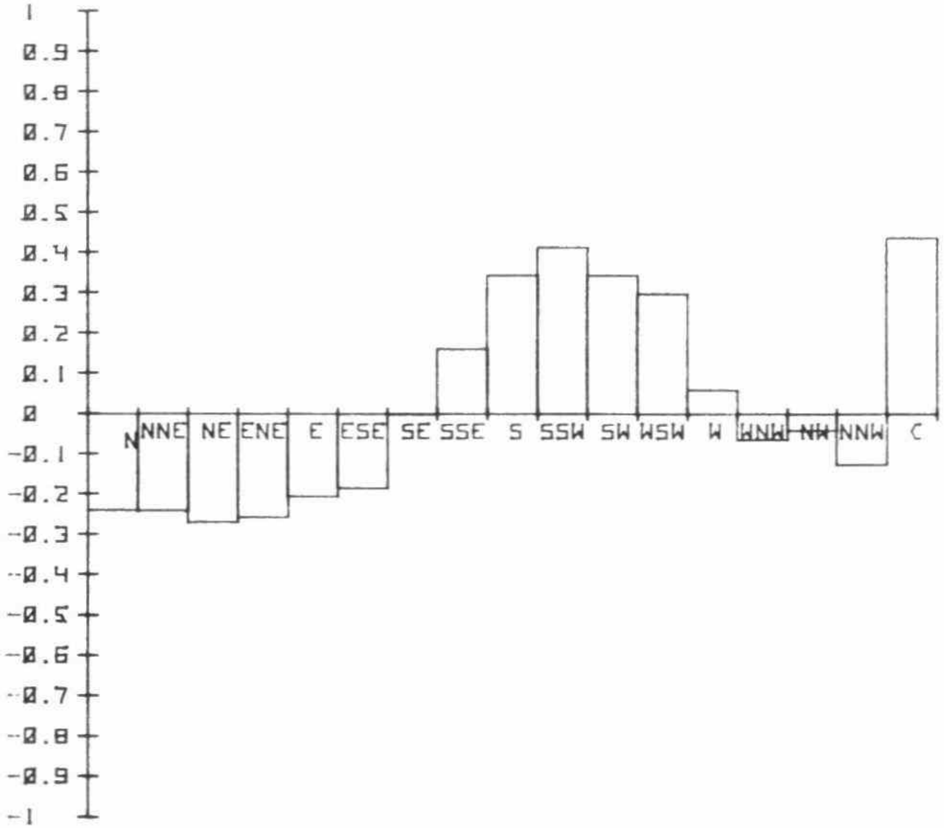


FIG. 6.1.3-1 - LOCATION OF AIR MONITORING STATIONS NEAR CANADA METAL CO.

FIG. 6.1.3-2 STATION NO 31058 FROM 15/4/73 TO 29/3/74 122 READINGS

CORRELATION COEFFICIENTS OF PARTICULATE WITH WIND DIRECTION



CORRELATION COEFFICIENTS OF LEAD WITH WIND DIRECTION

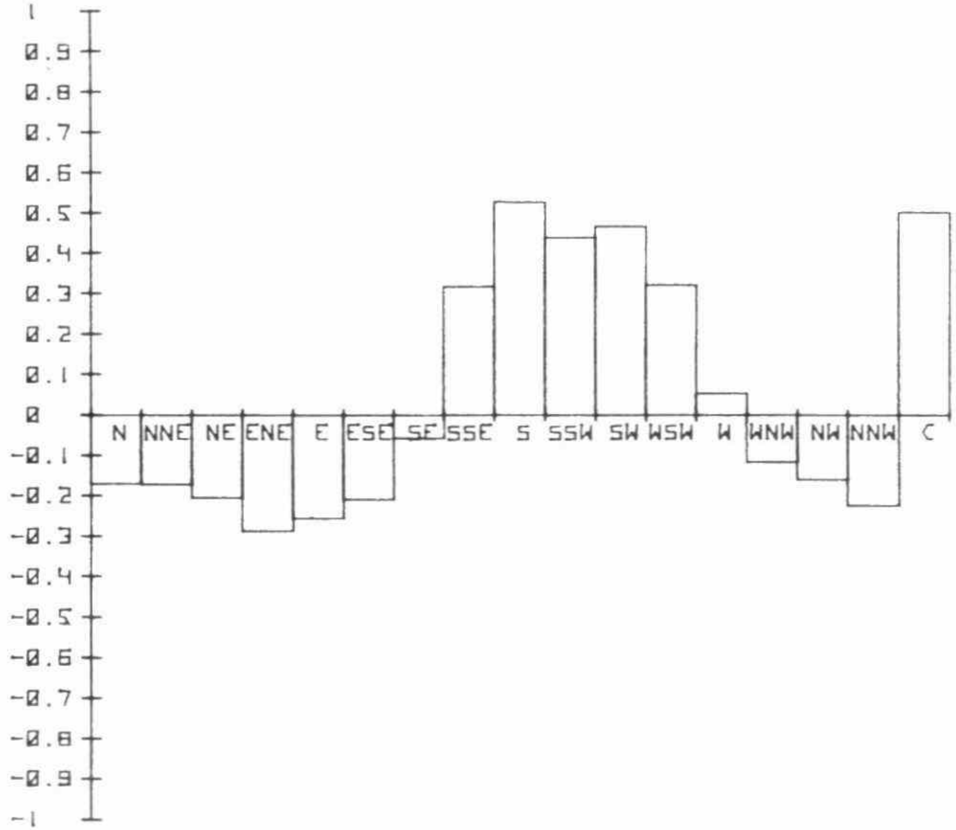
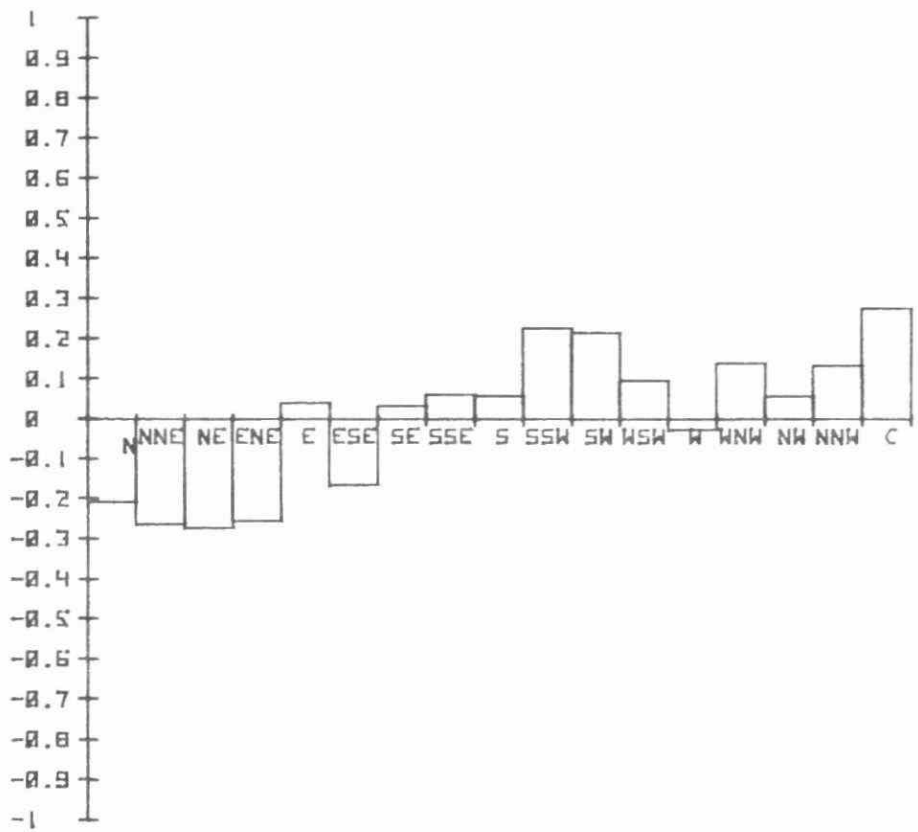
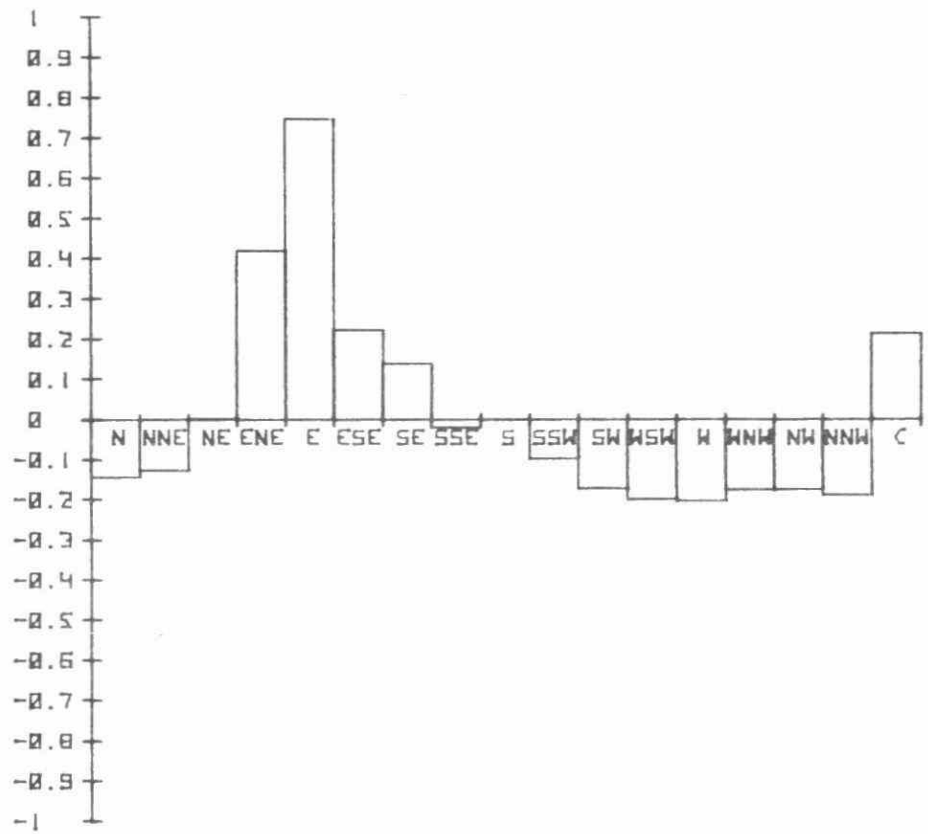


FIG. 6. 1. 3-3 CANADA METALS STATION NO 31065 - 97 READINGS FROM 9/12/73 TO 27/3/74

CORRELATION COEFFICIENTS
OF PARTICULATE WITH WIND
DIRECTION



CORRELATION COEFFICIENTS
OF LEAD WITH WIND
DIRECTION



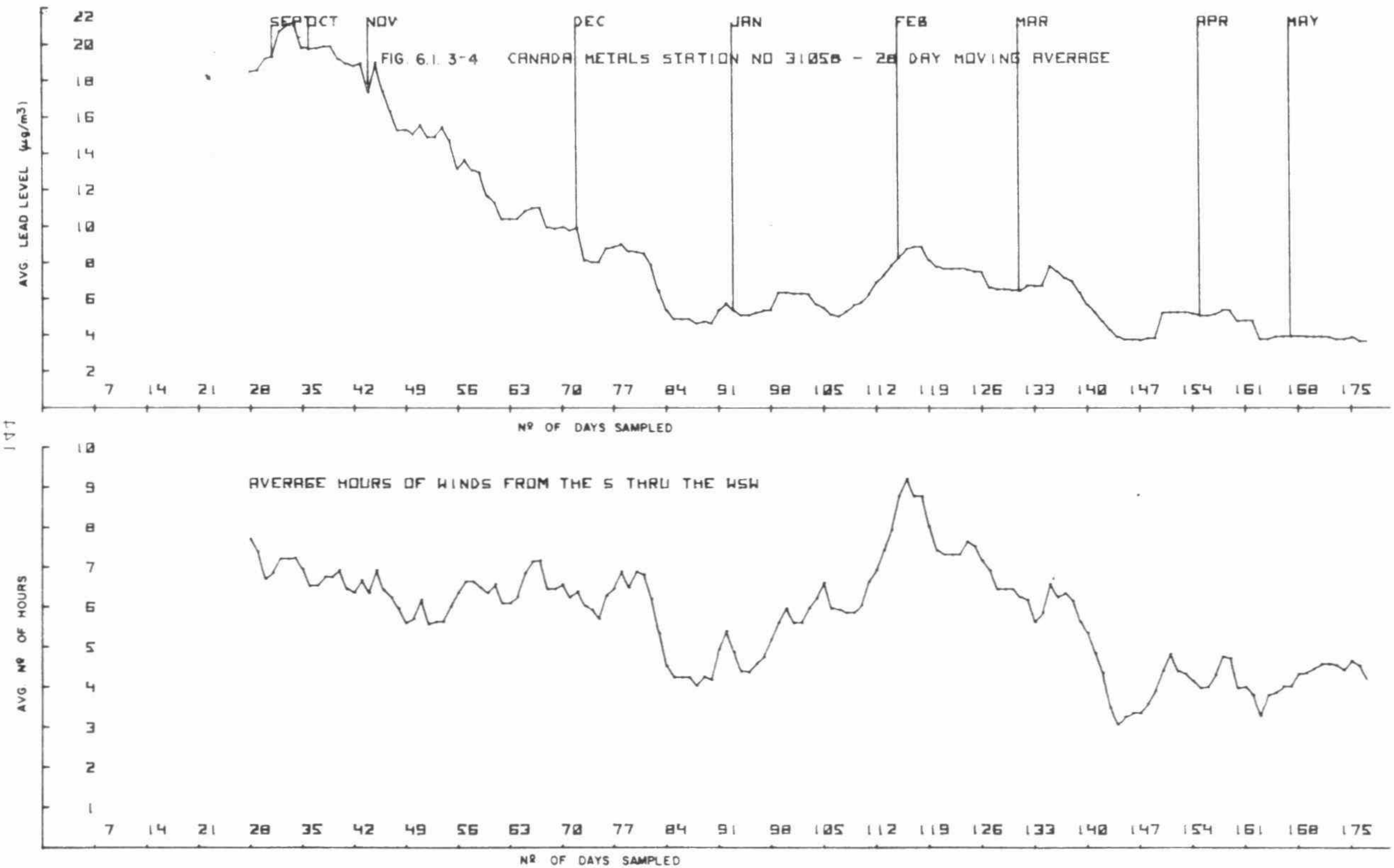


FIG. 6.1.3-4 CANADA METALS STATION NO 31058 - 28 DAY MOVING AVERAGE

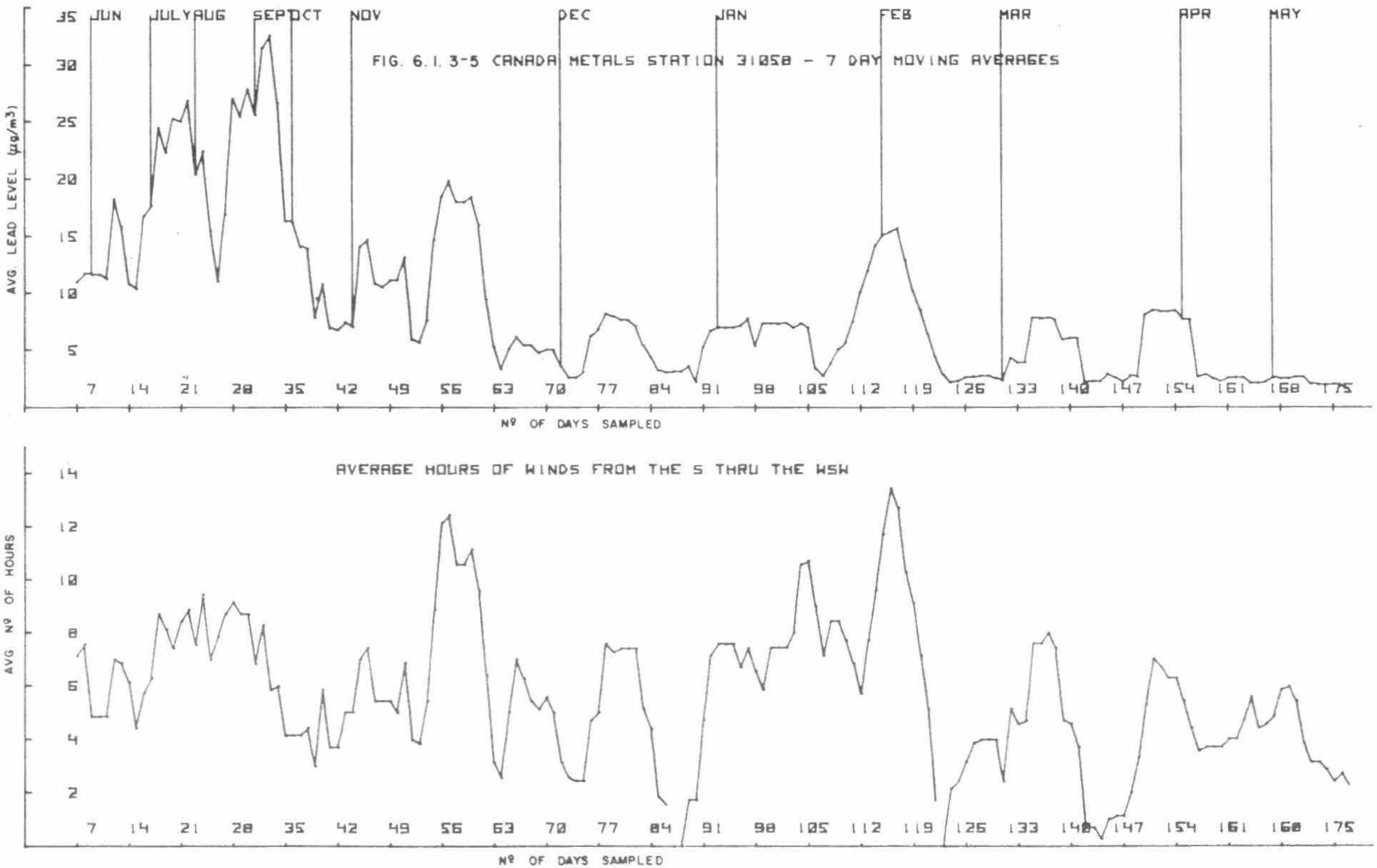


FIG. 6.1.3-5 CANADA METALS STATION 31058 - 7 DAY MOVING AVERAGES
JUN
JULY
AUG
SEPT
OCT
NOV
DEC
JAN
FEB
MAR
APR
MAY
AVG. LEAD LEVEL (µg/m3)
Nº OF DAYS SAMPLED
AVERAGE HOURS OF WINDS FROM THE S THRU THE WSW
AVG. Nº OF HOURS
Nº OF DAYS SAMPLED

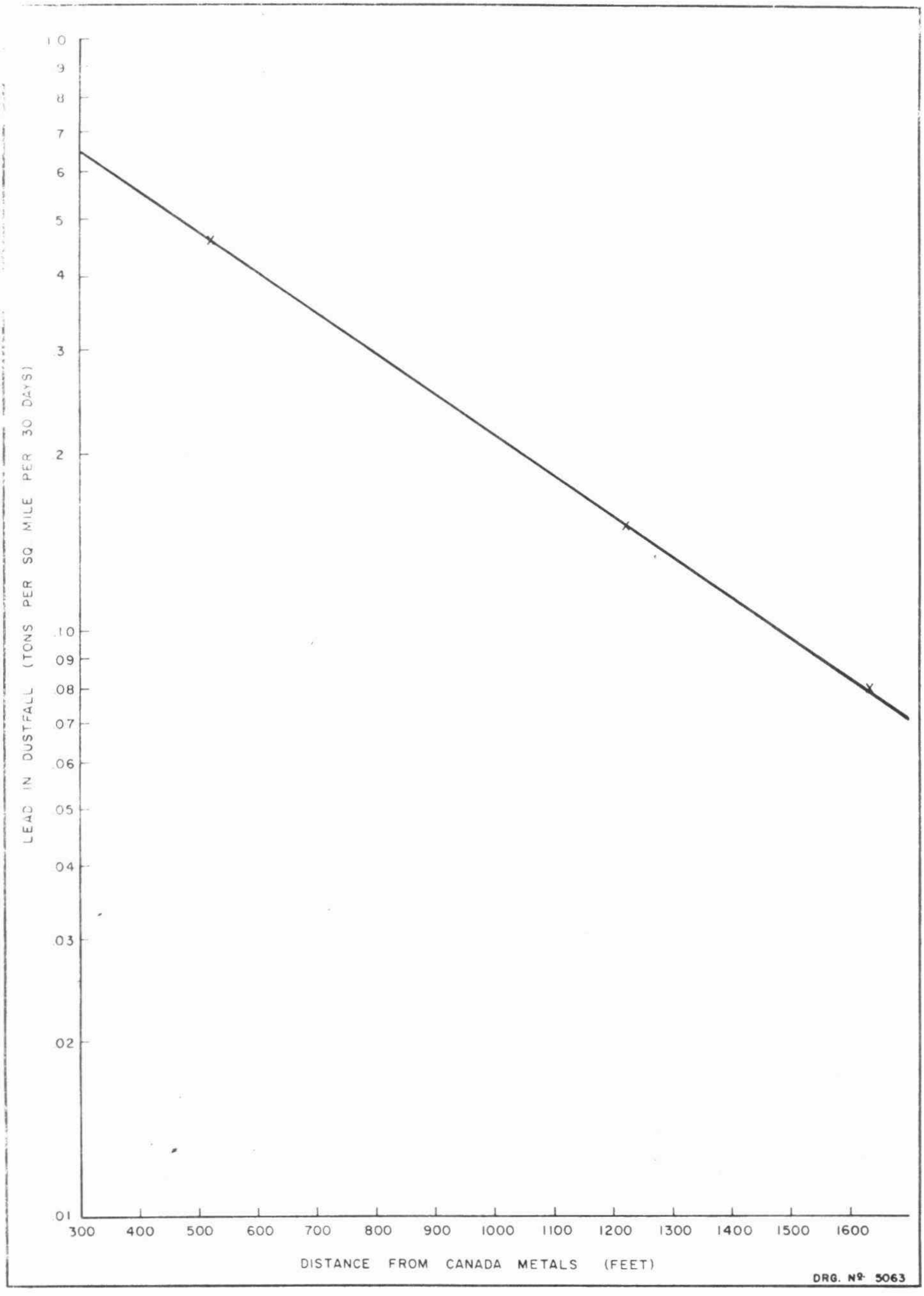
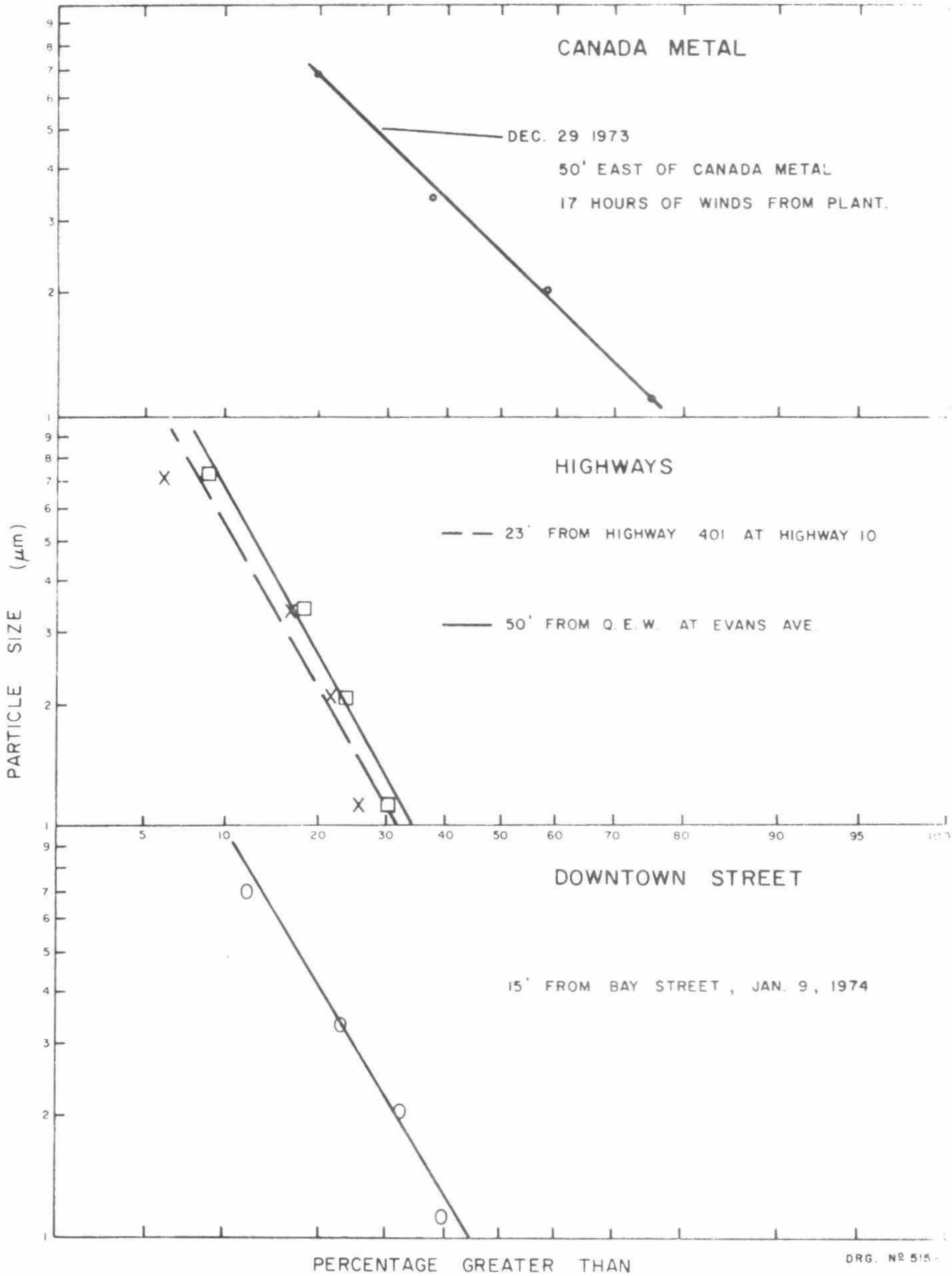


FIGURE 6.1.3-6 - AVERAGE LEAD IN DUSTFALL VS. DISTANCE FROM CANADA METALS



DRG. Nº 515

FIG.6.1.3-7 TYPICAL PARTICLE SIZE DISTRIBUTION FOR LEAD NEAR STREETS, HIGHWAYS, & CANADA METAL.

6.1.4 Summary of Lead Levels in Soil, Vegetation, and Snow in the Vicinity of Canada Metal Co. Ltd., 721 Eastern Ave., Toronto

The key conclusions of phytotoxicology assessment surveys conducted in the vicinity of Canada Metal in 1972, 1973 and 1974 are:

1) A survey conducted in September 1972 at 10 locations in the vicinity of Canada Metal demonstrated exceedingly high lead contents in surface soil (8,250 ppm) and in not washed vegetation (1800 ppm) at a distance of 200 feet north of the company. The not washed foliar samples possessed two to three times more lead than found in washed foliar samples. Lead levels in vegetation decreased with distance to the northeast from the Company.

2) The September 1972 survey was repeated one year later and the results showed similar trends in lead contents in soil and vegetation at the 10 locations in the vicinity of Canada Metal Co.

3) In November 1973, the survey was expanded to examine soil and vegetation at 40 stations in the vicinity of Canada Metal and at 11 control stations in the vicinity of the Gardiner Expressway in an area removed from the influence of industrial sources of lead. Excessive levels of lead were found in soil and in individual species of vegetation in residential areas to a distance of 1500 feet northeast of the company. Statistically significant decreases in lead content in both soil and vegetation were shown with increasing distances from Canada Metal to the north and northwest. No excessive levels of lead were found in control vegetation samples in the Gardiner Expressway area. Although higher than normal levels of lead were found in control soil samples near the Gardiner Expressway, the levels were considerably lower than those found near Canada Metal, particularly to the south of the Company.

4) An additional soil survey to indicate depth and extent of lead contamination in the vicinity of Canada Metal was conducted in November, 1973. Soil contamination isopleths were drawn on a map showing the areas north of the company possessing over 500 ppm lead in soil to various depths.

5) A snow sampling survey was conducted in February, 1974 in the vicinity of Canada Metal and the Toronto Board of Health Control Area. Two collections were made, one on February 7 immediately following a heavy snowfall, and the other on February 14 after the snow had been exposed for one week. The average percentage increase in lead in snow was found to be markedly greater in the Canada Metal area than in the Control Area.

Descriptions of these surveys follow, which include sampling locations, ... results and their interpretation.

6.1.4.1 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - September 20 - 22, 1972

Description of Investigation

This survey consisted of sampling Ailanthus trees, a shrub and soil from the 0-2 and 2-4 inch depths from 10 locations to the north, northeast, east, southeast, and northwest of the Canada Metal plant. A map showing the location of the sampling sites is attached.

Observation and Results

The lead content of collected foliar and soil samples is shown in Table 1. With one exception excessive levels of lead were detected in the washed foliage collected from Ailanthus trees and shrubs at all 10 sampling locations.

The lead levels were highest in the samples collected close to the Canada Metal Pla... and decreased with increasing sampling distance to the north and northeast of the source. Both the Ailanthus and shrub not washed foliage samples had two to three times the amount of lead as washed samples, indicating that significant proportio... of the airborne lead were deposited in the particulate form.

The lead content of soil collected from the 0-2 and 2-4 inch depths was found to be excessive at all 10 sampling stations, and generally, was highest in the surface layer.

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FIG. 1 - VEGETATION AND SOIL SAMPLING LOCATIONS NEAR CANADA METAL SEPTEMBER 20-22, 1972

TABLE I

Lead Content of Vegetation and Soil
Vicinity of Canada Metal Co.,Toronto
September 20-22, 1972

Station No.	Distance and Direction	Lead Content (ppm - dry weight)					
		Ailanthus		Shrub		Soil	
		NW	W	NW	W	0-2	2-4
1	200' N	1800	900	870	350 (L)	8250	5750
2	400' N	185	100	280	150 (H)	1000	550
7	2500' N	115	76	-	-	-	-
5	200' NE	600	290	570	300 (L)	1030	1000
6	1000' NE	220	260	140	150 (L)	3080	3500
8	1800' NE	135	47	175	95 (L)	1000	750
9	1700' E	320	170	-	-	7630	2000
10	500' SSW	500	270	-	-	800	600
3	600' NW	190	130	350	150 (P)	5000	2500
4	1000' WNW	410	180	1200	420 (H)	4880	2500
Control	1.3 mile NE	53	38	45	45 (L)	120	85
				63	48 (H)		

NW - not washed
W - washed
(L) - lilac
(H) - honeysuckle
(P) - privet

6.1.4.2 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - September 17, 1973

Description of Investigation

Soil and Vegetation Survey

This survey was conducted to determine the degree and extent of lead contamination of soil and vegetation in the vicinity of the Canada Metal plant. Sampling of Ailanthus or maple, lilac or substitute shrub and soil at depths of 0-2 and 2-4 inches was conducted at the same time of the year (September) and from the same locations as the previous 1972 survey. Additional sampling sites were located along Berkshire Avenue, north of the source, and in Leslie Grove Park, along Queen Street.

Observations and Results

Lead Content of Vegetation

The chemical analyses results for tree and shrub foliage are given in Table 1A. Elevated lead levels were found in all vegetation samples collected south of Queen Street, between Leslie Street and Winnifred Avenue. Highest lead levels were found in vegetation growing directly north and northeast of Canada Metal, and lead levels decreased with increasing distances away from the lead plant. Samples of maple foliage collected along Berkshire Avenue, north of the plant were compared with similar samples collected near the Gardiner Expressway and wth the average lead content of maple foliage in Metro Toronto (Table 1B).

These results showed that lead levels decreased with increasing distance from the source, and that the lead content of maple foliage collected 300 feet north of Canada Metal were 1.5 times higher for washed foliage and twice as high for not washed foliage when compared to maples growing next to the Gardiner Expressway.

Lead Content of Soil

Lead analyses of soil collected in the vicinity of Canada Metal are shown in Table 2. Significant lead contamination was found in all soil samples collected south of Queen Street, between Leslie and Winnifred. This pattern of contamination was similar to that found in vegetation samples. As with vegetation, lead levels in soil decreased with increasing distances away from the Canada Metal plant. The upper two inches of soil had significantly greater amounts of lead than lower levels of soil, indicating atmospheric deposition of the lead.

Comparison of 1972 and 1973 Results

A comparison of lead levels in vegetation and soil collected at the same locations in 1972 and 1973 is given in Table 3. Lead levels in Ailanthus and shrub foliage were relatively unchanged during the two years. Soil lead levels were variable, but no discernible trends, either decreasing or increasing, could be observed as a whole.

TABLE I

LEAD CONTENT OF VEGETATION COLLECTED AROUND
CANADA METAL , SEPTEMBER 17, 1973

A. Surveillance stations:

Station No.	Location	Lead Content (ppm - dry weight)			
		Ailanthus		Shrub	
		NW	W	NW	W
1	325' N	886	842	724	421
2	550' N	298	142	291	153
3	500' NW	337	194	179	79
4	700' NW	287	168	546	313
5	300' NE	556	329	435	309
6	750' NE	234	109	522	359
7	2000' N	98	45	87	42
8	1200' NE	111	57	181	71
9	900' E	265	190	-	-*
10	400' S	431	272	-	-
Control	3 miles W	82	37	83	49

* Shrub not available for sampling

B. Maple foliage:

Location of Sample	Lead Content (ppm- dry weight)	
	NW	W
300' N of Canada Metals	169	68
800' " "	92	77
1300' N " "	37	37
10' S of Gardiner Expy. at Bay St.	76	47
Metro Toronto Average	63	38

NW - not washed

W - washed

TABLE 2

LEAD CONTENT OF SOILS COLLECTED AROUND

CANADA METAL LTD., SEPTEMBER 17, 1973

Station	Location	Lead Content of Soil (ppm-dry weight)	
		0-2"	2-4"
1	325' N	2980	2700
2	550' N	1570	813
3	500' NW	2610	1710
4	700' NW	2470	2280
5	300' NE	3390	1620
6	750' NE	3310	2370
7	2000' N	218	238
8	1200' NE	665	695
9	900' E	2110	1300
10	400' S	765	510
CONTROL	3 miles W	225	200

TABLE 3

LEAD CONTENTS OF WASHED VEGETATION AND SOIL
0-2" COLLECTED AROUND CANADA METAL
IN SEPTEMBER 1972 AND SEPTEMBER 1973

Station No.	Location	Lead Content (ppm - dry weight)					
		Ailanthus		Shrub		Soil	
		1973	1972	1973	1972	1973	1972
1	325' N	842	900	421	350	2980	8250
2	550' N	142	100	153	150	1570	-
3	500' NW	194	130	79	150	2610	5000
4	700' NW	168	180	313	420	2470	4880
5	300' NE	329	290	309	300	3390	1030
6	750' NE	109	260	359	150	3310	3080
7	2000' N	45	76	42	-	218	-
8	1200' NE	57	47	71	95	665	1000
9	900' E	190	170	-	-	2110	7630
10	400' S	272	270	-	-	765	800
Control	3 miles W	37	38	-	-	225	365

6.1.4.3 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - November 2, 5, 6, 1973

Description of Investigation

An intensive survey of soil and vegetation was undertaken in order to define the extent of lead contamination in the vicinity of the Canada Metal Company. Samples of soil, at depths of 0-2 inches and 2-4 inches, and available vegetation (tree, shrub, grass) were collected at 300-foot intervals along eight directional lines radiating out from the plant; north, northeast, east, southeast, south, southwest, west, northwest. In addition to sampling in the vicinity of the plant, control samples were collected on a line running north and south of the Gardiner Expressway in the Exhibition Park area, based on a simulated source having the same position relative to the Expressway as the actual Canada Metal plant.

Half of each vegetation sample was washed prior to chemical analysis, and the remainder was analyzed unwashed.

Results of Chemical Analysis

Lead Content of Vegetation

The results of the chemical analysis for lead content of tree and shrub foliage are shown in Table 1. These results indicate a definite trend of reduced lead content in vegetation with increasing distance from the source. Along the radii running northeast, north, northwest and southwest from the plant, it was possible

to collect similar species of trees and shrubs at most stations. Consequently, the correlation between lead content of tree and shrub foliage and distance from the source was statistically significant for both washed and not washed samples collected along these radii.

The poor correlations in the other directions (east, west, south, southeast) can be attributed to the difficulty in locating species common to all sampling locations. Because vegetation was not plentiful to the south, southeast, and west of the plant, as well as the fact that autumn defoliation of many species had already occurred by the date of the survey, the choice of species from which samples could be obtained was greatly reduced. These factors are important in that different plant species show considerable variation in ability to accumulate airborne lead. However, the general trend of reduced lead content in vegetation with increasing distance from the source is still evident along three of these radii (east, south and southeast) when the lead contents of grass samples are examined. The correlation between lead content of grass and distance from the source is significant for both washed and not washed samples collected east of the plant,and significant for not washed samples collected south and southeast of the plant.

Figures 1 and 2 show zones of lead contamination in tree and shrub foliage (not washed and washed samples respectively) in the vicinity of Canada Metal. Extremely high levels of lead (greater than 150 ppm) in washed vegetation were detected in the immediate vicinity of the plant in all directions. Lead levels considered excessive (greater than 150 (not washed) and 75 ppm (washed) respectively were detected in vegetation in an area which extended approximately 500 feet to the north and northwest of the plant, 800 feet ot the northeast of the plant, and 1000 feet to the east of

the plant. The excessive lead levels in vegetation reflect current emissions of lead in the vicinity of Canada Metal.

Lead Content of Soil

Lead levels in soil samples collected in the vicinity of Canada Metal are shown in Table 2. The trend of reduced lead content with increasing distance is evident in all directions except west and southwest. The correlation between lead content in the 0-2" layer of soil and distance from the source is statistically significant for samples collected to the north, northwest and south of the plant.

The lead content of soil to the west of the plant is high at a distance of 1500 feet. Several industries and heavy traffic on Eastern Avenue may be a contributing factor in the wide distribution of lead in this direction.

Figure 3 shows isopleths of lead content in soil (0-2") depth in the vicinity of Canada Metal. The 5000 ppm isopleth indicates the area of extremely high lead and extends 1200 feet to the east and southwest. The excessive lead levels in soil reflect both current emissions of lead and residual contamination in the vicinity of Canada Metal.

Comparison with Control Samples (Gardiner Expressway)

Control samples for the Canada Metal Survey were collected in the Exhibition Park area, an area removed from the influence of industrial source of lead. A simulated source was located on Jefferson Avenue the same distance north of the Gardiner

Expressway as the Canada Metal Company on Eastern Avenue. Using the hypothetical position as a base, samples were collected at 300-foot intervals to the north and south of the assumed source in the same manner as sampling was carried out in the vicinity of Canada Metal. This control survey was designed to determine if vehicle emissions from an elevated expressway could be significant in contributing to higher than normal lead levels as found in the vicinity of Canada Metal. The locations of the control stations are shown in Figure 4.

Table 3 shows a comparison of results between the two areas with respect to lead content in vegetation and soil. In examining these results it must be noted that the Gardiner Expressway is located at a distance approximately 700 feet south of Canada Metal and the same distance south of the simulated source in the control area.

It can be seen from these results that washed vegetation samples collected in the control area did not exceed 75 ppm, indicating that vegetation in the control area does not contain higher than normal levels of lead. In contrast, several samples of washed vegetation collected in the vicinity of Canada Metal at comparable distances from the Expressway contained greater than 75 ppm lead, particularly to the south of the plant.

There is a noticeable decrease in lead content in vegetation with increasing distance from the Gardiner Expressway in the control area, but the values do not approach the high levels found in vegetation surrounding Canada Metal Company. This indicates that vehicle emissions alone could not account for the high lead content in vegetation in the vicinity of Canada Metal.

TABLE I

AVERAGE LEAD LEVELS IN WASHED AND NOT WASHED VEGETATION
COLLECTED IN VICINITY OF CANADA METAL
IN PARTS PER MILLION, DRY WEIGHT,
(NOVEMBER 2,5 AND 6/73)

Distance from Source	Direction															
	E		NE		N		NW		W		SW		S		SE	
	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W	NW	W
A. Tree and Shrub Foliage																
300'	258	183	451	308	94	90	145	123	108	77	-	-	-	-	268	400
600'	355	303	186	108	75	62	53	34	82	54	199	139	3530	2740	-	-
900'	167	115	33	32	59	50	40	35	96	72	143	92	105	123	480	290
1200'	-	-	121	61	39	25	52	34	-	-	54	54	-	-	138	122
1500'	63	60	90	54	53	31	26	30	81	72	117	86	123	108	-	-
1800'	-	-	43	35	-	-	-	-	-	-	63	60	-	-	-	-
Correlation Coefficient r=	-0.73	-0.60	-0.89**	-0.89**	-0.93**	-0.97**	-0.90*	-0.86*	-0.74	-0.07	-0.84*	-0.84*	-0.83	-0.83	-0.06	-0.90
B. Forage (grass)																
300'	-	-	111	42	159	112	119	26	287	134	-	-	-	-	-	-
600'	357	281	83	62	58	15	69	25	230	98	122	84	568	104	320	430
900'	139	98	42	20	413	102	62	29	275	143	18	18	305	219	183	156
1200'	131	37	135	42	-	-	29	24	55	25	37	19	94	61	-	-
1500'	78	37	79	46	25	34	41	28	51	24	22	16	62	41	103	101
1800'	-	-	-	-	-	-	-	-	-	-	44	21	-	-	-	-
Correlation Coefficient r=	-0.93*	-0.94*	-0.14	-0.15	-0.06	-0.47	-0.96**	-0.22	-0.80	-0.74	-0.68	-0.79	-0.98**	-0.48	-0.98*	-0.91

* Significant at 5% level　　　** Significant at 1% level

TABLE 2

LEAD CONTENT OF SOIL COLLECTED IN VICINITY OF CANADA METAL
IN PARTS PER MILLION, DRY WEIGHT
(NOVEMBER 2,5, AND 6/73)

Distance from Source	Direction															
	E		NE		N		NW		W		SW		S		SE	
	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"
300'	5380	6200	1350	1360	1100	863	1210	1330	1920	1710	-	-	-	-	8580	-
600'	1650	1660	2440	1660	505	385	538	445	3600	3400	5700	3030	21200	555	13400	12400
900'	2300	2260	770	755	810	728	445	335	1140	1360	620	418	9700	7880	943	175
1200'	4650	795	1590	1350	133	135	415	318	1920	733	378	205	1990	1950	605	220
1500'	613	83	663	368	320	243	240	223	1090	1100	720	608	1180	495	378	145
1800'	-	-	318	195	-	-	-	-	-	-	2090	1310	-	-	-	-
Correlation Coefficient r=	-0.56	-0.93**	-0.57	-0.73	-0.82*	-0.77	-0.95**	-0.90*	-0.42	-0.50	-0.63	-0.58	-0.98**	-0.12	-0.74	-0.35

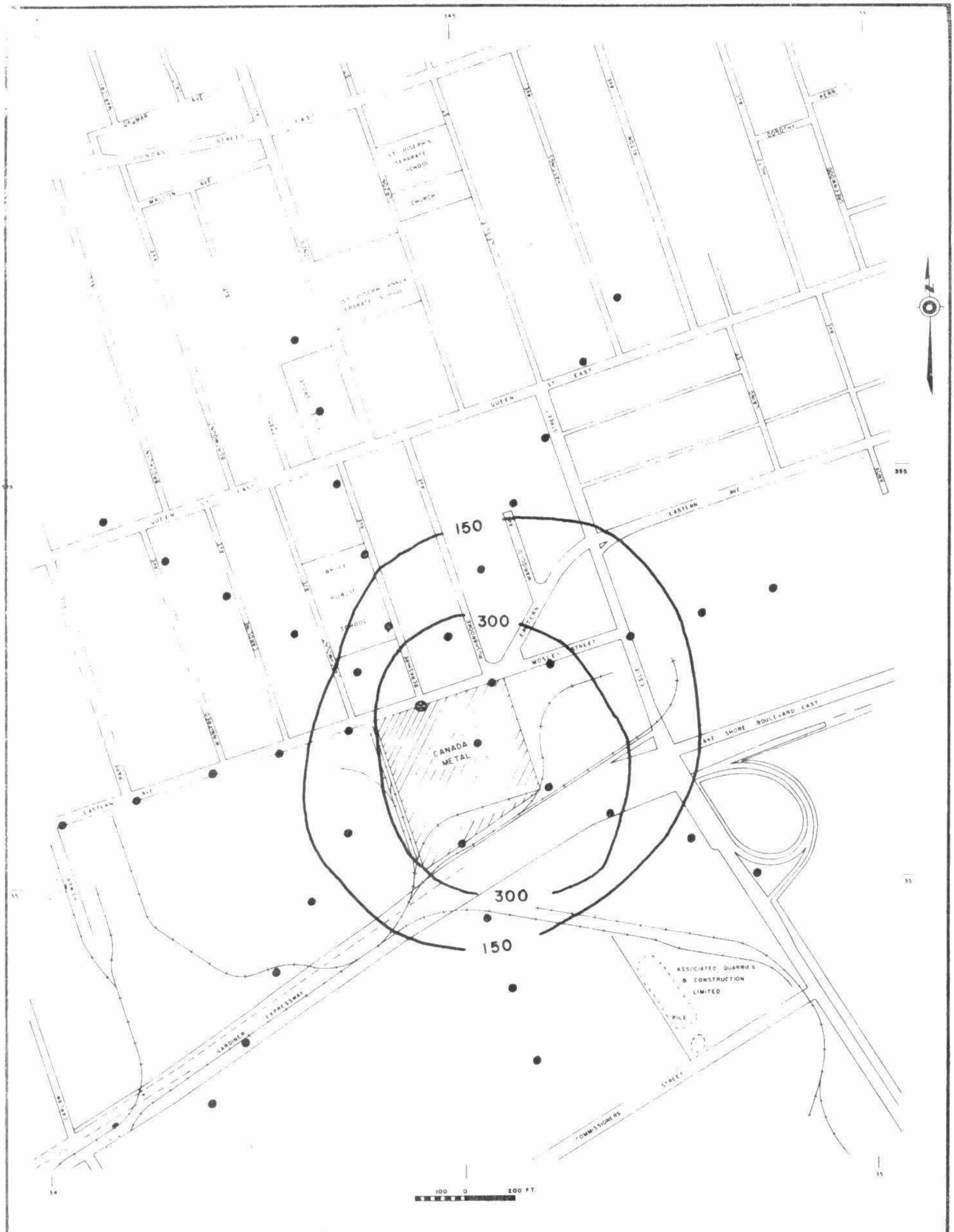
Metro Toronto Average 0-1" 291
4-6" 148

*Significant at 5% level
**Significant at 1% level

TABLE 3

COMPARISON BETWEEN CANADA METAL AREA AND CONTROL AREA
WITH RESPECT TO LEAD CONTENT (PPM-DRY WEIGHT)
OF VEGETATION AND SOIL

Distance and Direction from Source (Simulated Source in Control)	Foliage				Forage (Grass)				Soil			
	Control Stations		Canada Metal Stations		Control Stations		Canada Metal Stations		Control Stations		Canada Metal Stations	
	NW	W	NW	W	NW	W	NW	W	0-2"	2-4"	0-2"	2-4"
1500 feet N	32	23	53	31	23	20	25	34	610	338	320	243
1200 feet N	44	33	39	25	42	20	-	-	403	413	133	135
900 feet N	77	56	59	50	34	21	413	102	240	180	810	728
600 feet N	50	50	75	62	42	31	58	15	743	568	505	385
300 feet N	-	-	94	90	36	23	159	112	583	610	1100	863
300 feet S	79	63	-	-	24	20	-	-	648	388	-	-
600 feet S	-	-	3530	2740	64	48	568	104	160	113	21200	555
700 feet S	Location of Gardiner Expressway											
900 feet S	67	75	105	123	-	-	305	219	183	153	9700	7880
1200 feet S	27	18	-	-	-	-	94	61	93	55	1990	1950
1500 feet S	18	18	123	108	23	23	62	41	80	43	1180	495



6. 1. 4. 3.

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FIG. 1 - ZONES OF LEAD CONTAMINATION (IN ppm) IN UNWASHED TREE AND SHRUB FOLIAGE NEAR CANADA METAL CO. - NOV., 1973

FIG. 2 - ZONES OF LEAD CONTAMINATION (IN ppm) IN WASHED TREE AND SHRUB FOLIAGE NEAR CANADA METAL - NOV., 1973

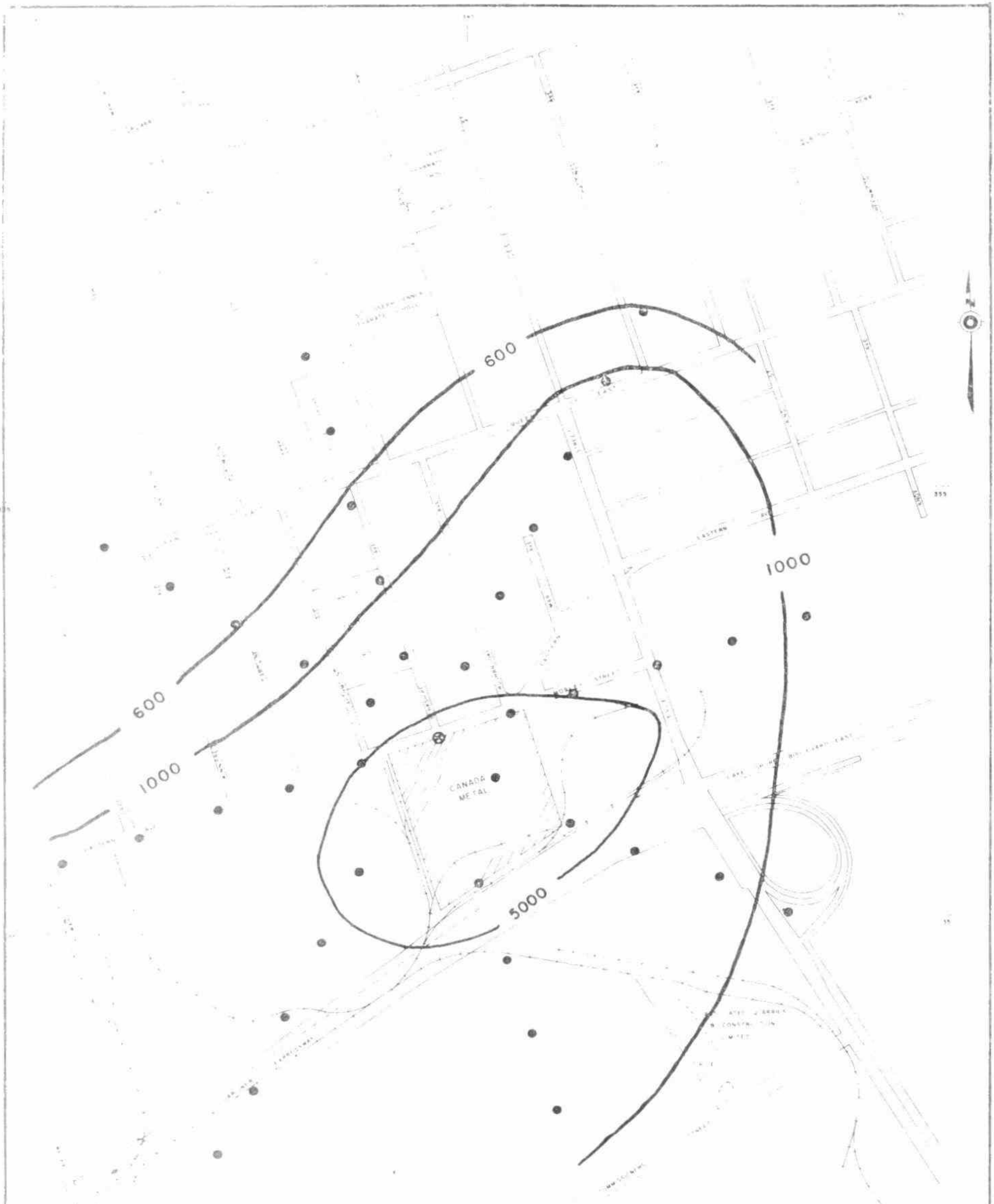


FIG. 3 - ZONES OF LEAD CONTAMINATION (IN ppm) IN SURFACE SOIL (0-2" DEPTH) NEAR CANADA METAL CO. - NOV., 1973

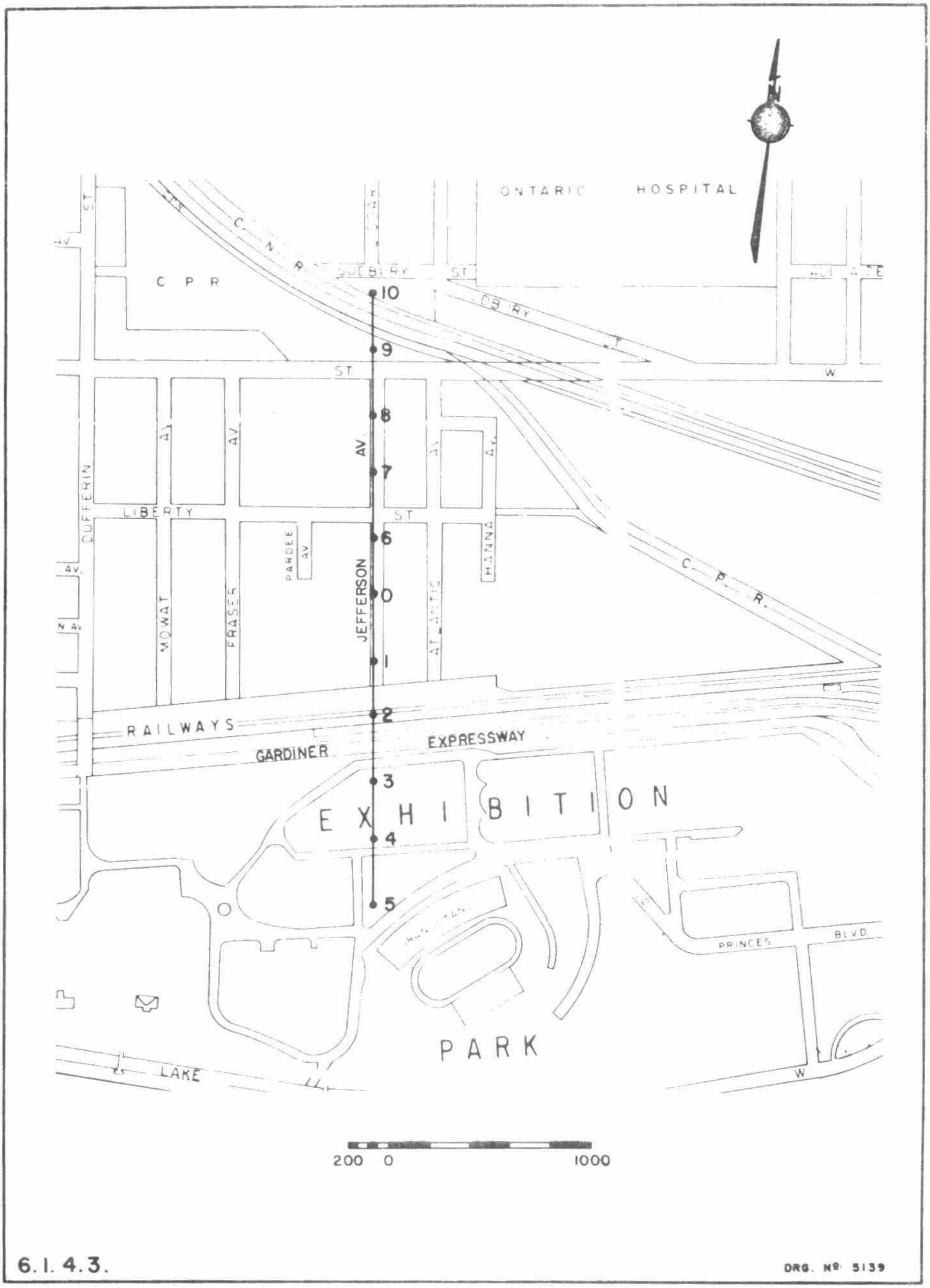


FIGURE 4 - LOCATIONS OF CONTROL STATIONS FOR SURVEY OF NOVEMBER 2-6, 1973

Soil samples (0-2") collected in the control area contain higher than normal levels of lead at the following stations: 300 feet south, 300 and 600 feet north, and 1500 feet north. However, the levels at these locations are still considerably less than the lead content of soil (0-2") collected in the vicinity of Canada Metal, particularly to the south of the plant.

6.1.4.4 Phytotoxicology Assessment Survey for Depth of Lead Contamination in Soil - November 19 - 20, 1973

Description of Investigation

A soil sampling program was conducted in the residential areas in the vicinity of Canada Metal in order to achieve the following objectives:

1) To determine the depth to which soil is contaminated in the vicinity of the company in the event that replacement is necessary, and

2) To study the possibility of any lead contamination in the soil originating from lower geological materials.

Soil samples were collected on four directional lines (northeast, north, northwest ad west) radiating out from the source and intersecting adjacent residential areas. Sampling locations were located at 300-foot intervals along each radius. At each station, a soil sampleswas taken at a depth of 0-4", 4-8", 8-12", and at a depth of 12-16" where possible.

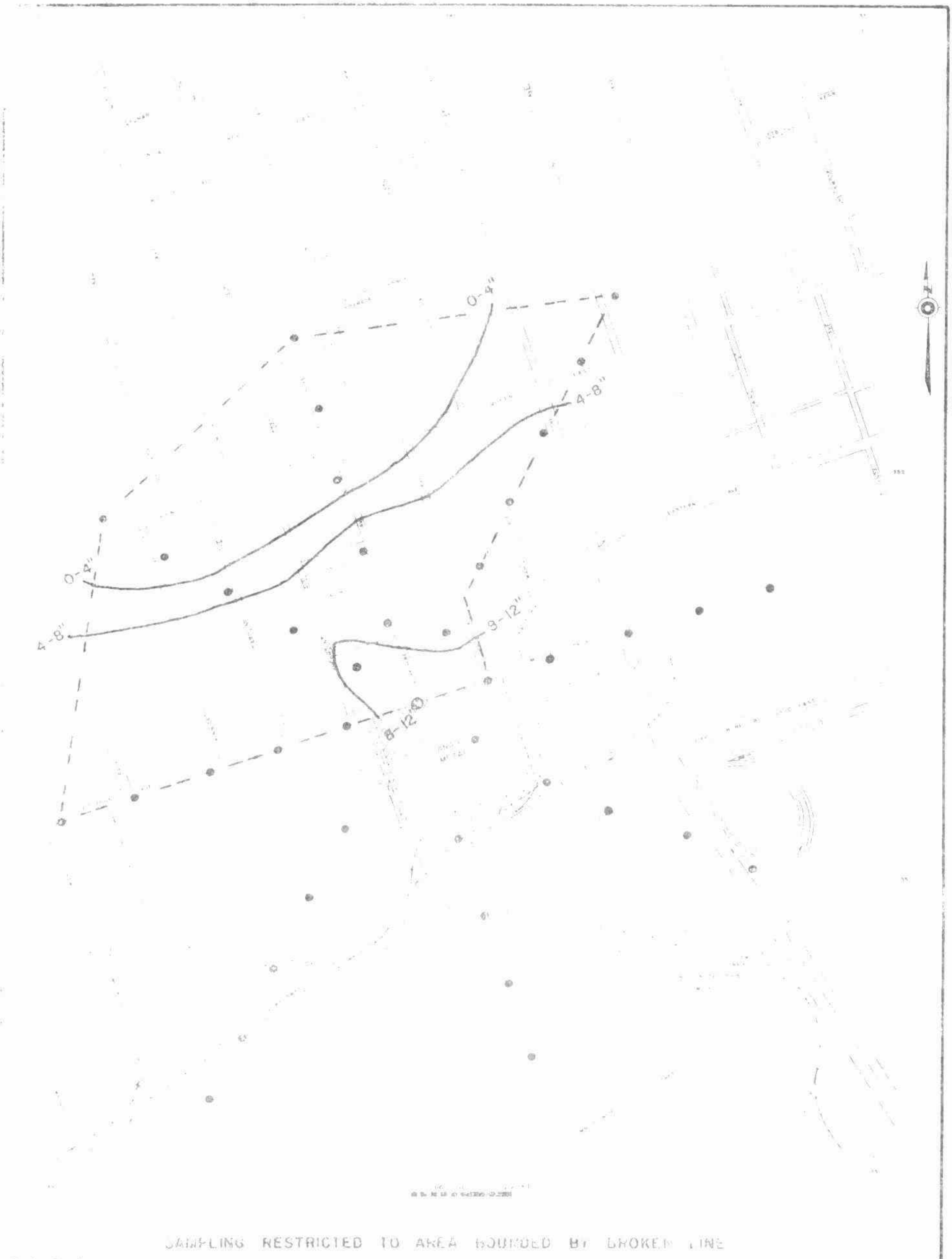
Observations and Results

The lead content of all soil samples is shown in Table 1. Using the value of 500 ppm as an indication of excessive lead levels in soil, contamination isopleths for each of

TABLE I

LEAD CONTENT OF SOILS COLLECTED IN THE VICINITY OF CANADA METAL , NOVEMBER 19, 1973

Station No.	Distance from Source	Lead content (ppm dry weight)			
		0-4"	4-8"	8-12"	12-16"
0	Source	5280	1150	328	-
1	300' E	5350	1080	978	-
6	300' NE	700	750	385	-
7	600' NE	630	253	380	513
8	900' NE	1410	268	168	-
9	1200' NE	1690	740	320	-
10	1500' NE	145	130	35	-
10 A	1800' NE	870	798	28	-
11	300' N	875	1900	395	348
12	600' N	405	623	188	170
13	900' N	798	330	130	60
14	1200' N	188	185	138	53
15	1500' N	148	53	30	28
16	300' NW	513	1080	1100	170
17 A	800' NNW	218	38	43	-
17	600' NW	583	403	168	90
18	900' NW	820	775	228	80
19	1200' NW	318	103	40	18
20	1500' NW	395	208	73	13
21	300' W	2280	743	80	68
22	600' W	1430	535	288	78
23	900' W	1380	1050	210	73
24	1200' W	1390	428	128	178
25	1500' W	1400	898	195	63



6.1.4.4.

FIG. I - DEPTH OF SOIL CONTAMINATION NEAR CANADA METAL
NOVEMBER 19-20, 1973.

three soil depths have been drawn on the attached map (Figure 1). This map could be used as a basis for determining excavation depth in the event that soil replacement becomes necessary. Since sampling was restricted to the residential area within the west and northeast radii, isopleths surrounding the plant could not be drawn.

It is apparent from this map that lead is not originating from lower geological materials, since the severity of contamination at lower soil depths was found to decrease with increasing distance from the plant.

6.1.4.5 Phytotoxicology Assessment Survey for Lead in Snow February 7, 14, 1974

On February 7, 1974, following a snowfall during the preceding night and early morning of that day, a snow sampling program was initiated in the vicinity of Canada Metal Company Limited. Ten sampling sites were selected; 7 in the close vicinity of the company and three in the Toronto Board of Health Control Area. On February 14, 1974, snow exposed for one week was collected at the same 10 locations. The locations of the sampling sites are described in Table 1 and shown in Figure 1.

Methods

Snow was collected into clean plastic bags with a rectangular bladed, garden-type shovel. The available depth of snow above the grass or gound level at each sampling site was collected. On February 7 this ranged between 3 and 6 inches; on February 14 rarely more than a 2 to 3 inch depth was available at any site. The snow was collected carefully in order to exclude grass or soil from the samples.

On February 7 approximately 24 litres of snow were collected at each site. This volume was found to exceed analysis requirements and consequently on February 14 approximately 12 litres of accumulated snow was collected at each site.

Snow was transported to the laboratory and allowed to melt in the plastic bags. Samples were acidified with 1 drop of concentrated nitric acid per 32 oz. bottle of melt. Analyses were performed on the melts for lead, cadmium, chromiun, iron, vanadium and zinc. The pH of each snow sample was taken prior to acidification.

Results

The results of the chemical analysis of freshly fallen snow are given in Table 2, and the results for the week-old snow are given in Table 3. Significant increases in heavy metal concentrations were observed for lead, iron, vanadium and zinc over the one-week exposure period for snow collected from all stations. Cadmium and chromium were low and relatively unchanged at all stations. The pH of the aged snow was found to increase significantly at all stations.

When the snow sampling sites were grouped according to distance and direction from Canada Metal, an apparent gradient of lead concentrations were observed (Table 4). Similar gradients were not observed for the other heavy metals, although iron and zinc levels at sampling sites closest to Canada Metal were higher than at other stations.

TABLE I

LOCATIONS OF SNOW SAMPLING STATIONS
IN THE VICINITY OF CANADA METAL CO. LTD. - FEBRUARY 7, 1974

Stations No.	Distance & Direction from property perimeter	Location
1	700' NE	north end of lane between Rushbrooke and Marigold Avenues - 5 Marigold (backyard)
2	450' NE	backyard 22 Marigold Ave.
3	325' NE	backyard 4 Marigold Ave.
4	325' E	front yard 18 Mosley St.
5	300' N	backyard 24 Rushbrooke Ave.
6	75' N	front lawn 7 Berkshire Ave.
7	50' SE	50' SE of Canada Metal (AMB soil & vegetation collection station #37)
8	1 mile W	Control Zone - south (dead) end of Saulter St. in Small open area opposite end houses
9	1 mile W	Control Zone - north perimeter of YMCA playing field; off Broadview north of Allen Ave.
10	1 mile W	Control Zone - behind apartment, near N. perimeter hedge, at 444 Logan Ave.

TABLE 2

HEAVY METAL CONTENT OF FRESHLY-FALLEN SNOW COLLECTED AROUND CANADA METALS AND IN THE GERRARD ST. CONTROL ZONE, IN ug/ml FEBRUARY 7, 1974

Station No.	Location	Pb	Cd	Cr	Fe	V	Zn	pH
1	52 Marigold	0.10	<0.01	<0.01	0.61	0.01	0.05	-
2	22 Marigold	0.16	0.01	0.01	0.53	0.04	0.04	-
3	4 Marigold	0.15	0.01	0.01	0.44	0.03	0.06	-
4	18 Mosley	0.46	0.01	0.01	0.75	0.01	0.05	6.3
5	24 Rushbrooke	0.24	0.01	0.01	0.28	0.01	0.06	5.4
6	7 Berkshire	0.59	0.01	0.01	0.86	0.01	0.05	6.4
7	50' SE	0.51	0.01	0.01	0.70	0.03	0.04	5.7
8	Control	0.19	0.01	0.01	0.78	0.01	0.03	6.1
9	Control	0.09	0.01	0.01	0.35	0.03	0.04	5.2
10	Control	0.10	0.01	0.01	0.84	0.01	0.04	6.5

TABLE 3

HEAVY METAL CONTENT OF ONE-WEEK-OLD SNOW COLLECTED AROUND CANADA METALS AND IN THE GERRARD ST. CONTROL ZONE, IN ug/ml FEBRUARY 14, 1974

Station No.	Location	Pb	Cd	Cr	Fe	V	Zn	pH
1	52 Marigold	0.50	<0.01	0.01	1.8	0.09	0.20	6.8
2	22 Marigold	0.90	0.01	0.01	1.7	0.06	0.16	6.1
3	4 Marigold	1.0	0.01	0.01	1.3	0.11	0.15	6.2
4	18 Mosley	3.56	0.01	0.04	3.7	0.09	0.35	7.2
5	24 Rushbrooke	0.81	0.01	0.01	2.0	0.15	0.28	6.9
6	7 Berkshire	2.06	0.01	0.04	2.5	0.06	0.34	7.2
7	50' SE	13.8	0.01	0.03	5.7	0.06	0.49	7.2
8	Control	0.23	0.01	0.01	2.4	0.06	0.15	7.1
9	Control	0.21	0.01	0.01	1.6	0.06	0.16	7.1
10	Control	0.19	0.01	0.01	1.5	0.06	0.36	7.2

TABLE 4

COMPARISON BY DISTANCE AND DIRECTION FROM CANADA METAL
OF HEAVY METAL CONTENT OF EXPOSED SNOW
COLLECTED ON FEBRUARY 14, 1974, IN ug/ml

Location	Distance & Direction from Canada Metals	Pb	Fe	V	Zn
50' SE	50' SE	13.8	5.7	0.06	0.49
18 Mosley	325' E	3.56	3.7	0.09	0.35
4 Marigold	325' NE	1.0	1.3	0.11	0.15
22 Marigold	450' NE	0.90	1.7	0.06	0.16
52 Marigold	700' NE	0.50	1.8	0.09	0.20
7 Berkshire	75' N	2.06	2.5	0.06	0.34
24 Rushbrooke	300' N	0.81	2.0	0.15	0.28
Control	1 mile W	0.23	2.4	0.06	0.15
Control	1 mile W	0.21	1.6	0.06	0.16
Control	1 mile W	0.19	1.5	0.06	0.36

TABLE 5

PER CENT INCREASE IN LEAD AND IRON CONTENTS OF SNOW EXPOSED FOR ONE WEEK AROUND CANADA METAL AND IN CONTROL ZONE, IN ug/ml

Location	Pb (ug/ml)		% increase	Fe (ug/ml)		% increase
	Feb.7	Feb.14		Feb.7	Feb.14	
50' SE	0.51	13.8	2610	0.70	5.7	710
18 Mosley	0.46	3.56	670	0.75	3.7	390
4 Marigold	0.15	1.0	570*	0.44	1.3	195
22 Marigold	0.16	0.90	460*	0.53	1.7	220
52 Marigold	0.10	0.50	400*	0.61	1.8	195
7 Berkshire	0.59	2.06	250	0.86	2.5	190
24 Rushbrooke	0.24	0.81	240	0.28	2.0	610
Control	0.19	0.23	20	0.78	2.4	210
Control	0.09	0.21	130	0.35	1.6	360
Control	0.10	0.19	90	0.84	1.5	80

* Correlation coefficient; r =-0.98 was calculated for 3 locations with increasing distance to the northeast and % increase in lead in snow

6.1.4.5.

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FIG. 1 - SNOW SAMPLING LOCATIONS NEAR CANADA METAL - FEB. 7, 1974

The per cent increases in lead and iron content over the one week exposure period are compared in Table 5. There was relatively little difference in per cent increase in iron between stations around Canada Metal and stations in the control area. However, the per cent increase in lead in snow collected around Canada Metal was markedly higher than in snow from the control area.

This snow sampling program was experimental, and any conclusions derived from it must be regarded as tentative. However, these results suggest that snow in the vicinity of Canada Metal accumulated greater amounts of lead than snow in another area of the city.

6.1.5 Canada Metals Analysis

a) Abatement Activities

The measures taken by the Canada Metal Company Limited (see Section 6.1.2) have not caused a significant change in airborne lead concentrations and dust-fall near the plant but, there is evidence of a continuing small but significant downward trend in lead levels at the station closest to the plant starting in late 1973. Levels of lead in dustfall will still have to be reduced to meet the suggested desirable objective of 0.3 tons/mile^2/30 days within 250 feet of the plant.

b) Suspended Lead in the Vicinity of Canada Metals

The data collected by the Ministry of the Environment and presented in section 6.1.3 indicate that the incidence of levels of suspended lead above normal background and often in excess of the proposed air quality criteria at stations 31058, 31065

and 31045 is strongly correlated with winds from Canada Metals. Since the stations 31058 and 31065 are on opposite sides of the plant it must be that lead emissions from the plant override any contribution from other sources such as the Gardiner Expressway or Eastern Avenue. An analysis excluding days on which there were any winds from the direction of Canada Metals has confirmed that the influence of other sources is no more than 3 ug/m^3/24 hours.

The regression equation of Rutgers University (section 2.2.1)predicts levels of 1 ug/m^3 in summer and 2.1 ug/m^3 in winter at station 31058 due to the Gardiner Expressway or 1.8 ug/m^3 in summer and 2.9 ug/m^3 in winter due to Eastern Avenue. These levels do not reinforce due to wind direction.

The extent of the elevation of suspended lead levels is to distances up to 400 feet from the plant.

The size distribution of lead in suspended particulate matter indicates that the elevated lead levels are due to larger particles than normally associated with vehicular traffic and this change in size distribution occurs with winds from Canada Metals.

A portion of the emissions from Canada Metals is in the respirable range as is the bulk of traffic generated suspended lead.

Since late 1973 there has been a discernible downward trend in lead levels at station 31058. This could be due to:

i) abatement measures by Canada Metals

ii) lower production rates

iii) lower frequency of winds from the direction of the plant

iv) other meteorological factors

An analysis has shown that a portion of the drop in levels at the sampling station could be explained by a lower frequency of winds from the plant but there still remains a continuing improvement that cannot be adequately explained by decreased wind frequency. This may be the first indication of the success of abatement measures. There is no similar downward trend apparent at station 31065. More data are needed before firm conclusions will be possible but the results are encouraging.

c) Dustfall

Levels of lead in dustfall in the vicinity of Canada Metals continue to be above those normally found in urban areas and are probably in excess of the suggested desirable objectives of 0.3 tons/mile^2/30 days within 250 feet of the plant. The levels drop off rapidly with distance from Canada Metals.

Again there has been some apparent improvement in levels over those measured in 1973.

d) Soil Lead Levels

Phytotoxicology surveys conducted in 1972 and 1973 found excessive levels of lead in soil in residential areas to a distance of 1500 feet northeast from Canada Metals. Statistically significant decreases in the lead content of soil with distance from Canada Metals were found in the north, northwest and south directions. Although higher than normal lead levels were found at control sites along the Gardiner Expressway the levels were considerably lower than those found near Canada Metals where levels as high as 8250 ug/g were recorded.

Since the soil reflects the historical situation of lead contamination by airborne lead particularly settleable particles in dustfall it could be argued that the levels are due to past emissions from Canada Metals and other sources. This contention is not supported by the findings concerning the contamination of foliar vegetation in the area which are indicative of on-going contamination. Calculations of soil contamination rates by lead in dustfall near Canada Metal indicate that current dustfall levels are sufficient to cause lead contamination (600 ppm) of fresh soil in relatively short periods so that remedial clean up without a reduction in dustfall levels could only be a short-term remedial solution.

The results of a soil depth survey showed that excessive lead in soil occurs to depths of 8 - 12" immediately to the north of the plant with excessive lead in the surface layer, 0 - 4" being found as far north as Queen Street, the contamination again decreases with distance from Canada Metals.

Any soil removal and clean up program would not only have to remove a large area of soil but would also have to replace soil at depths up to one foot near the plant.

e) Vegetation Contamination

Phytotoxicology surveys conducted in the Canada Metal area showed that levels of lead in vegetation showed little change from 1972 to 1973. significant lead contamination of vegetation was found from Leslie Street in the east, north to Queen Street and west to Winnifred Street. The difference between not washed and washed samples indicated a high proportion of surface contamination and the lead levels decreased in a statistically significant manner with distance from Canada Metal to the north and northeast. The results indicated that during 1972 and 1973 there was on-going excessive contamination of foliar vegetation by dust and finely divided particles to distances of 1500 feet from Canada Metal.

Unless the on-going contamination of both vegetation and soil is arrested any remedial clean up and replacement of soil or turf can only be short term.

Summary

There is some encouraging evidence at this time that recent abatement measures at Canada Metal have had an effect. It appears at this time that despite a reduction in the degree of lead contamination the proposed air quality criteria of 5 $ug/m^3/24$ hours and 2 $ug/m^3/30$ days and the suggested desirable guideline of 0.3 $tons/m^2/30$ days for lead in dustfall will continue to be exceeded within 250 feet of the plant. This will require further action by the Company on the problem of control of fugitive emissions.

Soil lead levels will continue to be excessive up to 2000 feet from Canada Metal since lead in soil is relatively immobile and reflects past episodes of contamination.

It is anticipated that the extent of vegetation contamination will be reduced in 1974.

6.2 TORONTO REFINERS & SMELTERS LIMITED

6.2.1 Review of Plant Operations

The Company operates a smelting and refining process, using spent automobile batteries, and producing ingot lead and lead alloys. Production of lead is of the order of 15,000 tons per year.

The operation is continuous, on a 24 hours per day and seven days per week basis for the smelting process, and on a 24 hours per day and five days per week basis for the refining and alloying processes.

The main operations are depicted in process Flow Sheets, Nos. 1 through 3 and are as follows:

- a) Lead Recovery Operations
- b) Smelting Operations
- c) Refining and Alloying Operations

Emissions of lead indicated on the flow sheets and in Table No. 1 are based on calculations contained in the Interim Report on Lead dated December, 1973, and are updated to reflect the latest abatement activities (as at June, 1974). A summary of abatement activities is included in Section 6.2.2 of this report.

a) Lead Recovery Operations (Process Flow Sheet No. 1)

Receiving and Storage

Batteries and separated scrap are received by truck from various sources in Canada and the U.S.A. and are stored in outside storage piles.

Separation Processes

Battery tops are separated on a guillotine and are crushed, and the lead lugs and plate connectors stored in outside storage piles. Plates and grids are emptied from the cases and are also directed to the storage pile. Crushed plastic battery tops and cases are cleaned of lead and are disposed in an offsite dump area. Lead sulphate and oxide, washed off from battery cases, settles out as a sludge and is stored in outside storage piles. Acid from batteries is neutralized with soda ash, adjusted for pH, and directed to the sewer.

Emissions

Emissions from the battery top separator are controlled, using a settling chamber and a baghouse. Exhaust to atmosphere is through a separate stack (approximately 50 feet high). Emissions of acid like odours and particulate matter have been observed from time to time, from the following sources;

- guillotine penthouse
- battery case crusher
- battery storage pile
- recovered (scrap) lead storage piles

Smelting Operations (Process Flow Sheet No. 2)

Recovered (scrap) lead from a working pile within the smelter building is conveyed to a rotary drum feeder and then charged to the top of the reverberatory furnace for processing in an oxidizing environment. Product soft lead is collected in ingot form and is stored outside. Slag (or "reverb matt") is directed to the blast furnace.

Blast Furnace

Slag from the reverberatory furnace is charged to the blast furnace together with coke and scrap steel. Product "hard" lead is collected in ingot form and is directed for further processing in the refining and alloying operations. Slag from the blast furance is removed to an off site dump area.

Emissions

Exhaust gases from the reverberatory and the blast furnace, and containing suspended particulate matter, sulphur dioxide, and nitrogen oxides, are passed through hair pin coolers and the main baghouse, and then discharged through the main (62 foot) stack to the atmosphere.

Fumes from the tap holes of the reverberatory and the blast furnace are exhausted through two small baghouses (in parallel) to the atmosphere via the main stack.

Emissions have been observed from time to time from the reverberatory furnace charging operation as well as from the top of the blast furnace, especially during

upset conditions.

Refining and Alloying Operations (Process Flow Sheet No. 3)

Reverberatory metal ("soft" lead) and blast furnace metal ("hard" lead) are further refined and alloyed in furnaces (kettles) of various capacities. The products, which include pure lead, antimony lead alloy and other lead alloys are cast into ingots and are stored. The dross is collected for reprocessing in the reverberatory furnace.

Emissions

Emissions of fumes from all kettles are contained and are passed through the main baghouse, and are discharged to the atmosphere via the main stack.

6.2.2 Review of Abatement Activities

Following surveys and recommendations of Provincial Officers of the Ministry of the Environment, the Company was required and undertook the following actions:

a) all in-plant vehicular traffic routes have been paved with hard surface.

b) all traffic routes are swept continuously.

c) ready use raw material storage piles are covered with large plastic sheets and in-plant material handling has been containerized.

d) storage piles are watered or oiled before being worked.

e) truck tires are being water washed before the vehicle leaves the premises.

f) the battery top crusher has been relocated and controlled with an approved settling chamber, a bag filter and stack.

g) exhaust fume emissions from the slag tap and lead well, at each of the blast and reverberatory furnaces, have been controlled by the installation of exhaust hoods and ducts to direct the fumes to the main bag filter.

h) emissions from three, 40 ton capacity kettles previously fitted with exhaust hoods have been directed to the main bag filter during filling, refining, alloying and pouring.

i) the remaining five smaller kettles have been ducted to the main bag filter.

j) the rotary furnace has been shut down. This process cannot be restarted without approval from the Ministry.

The only item still outstanding is the construction of a 175 foot chimney stack to disperse SO_2 emissions to Ministry's standards and to further reduce residual lead concentrations from the main bag filter. A Certificate of Approval has been issued by the Ministry for the construction of the stack. Completion of this item is dependent on the company receiving a building permit from the City.

A further requirement of the Medical Officer of Health that the company construct a building to enclose long term stockpiles of lead bearing raw materials has been held up pending resolution of additional requirements for the enclosure.

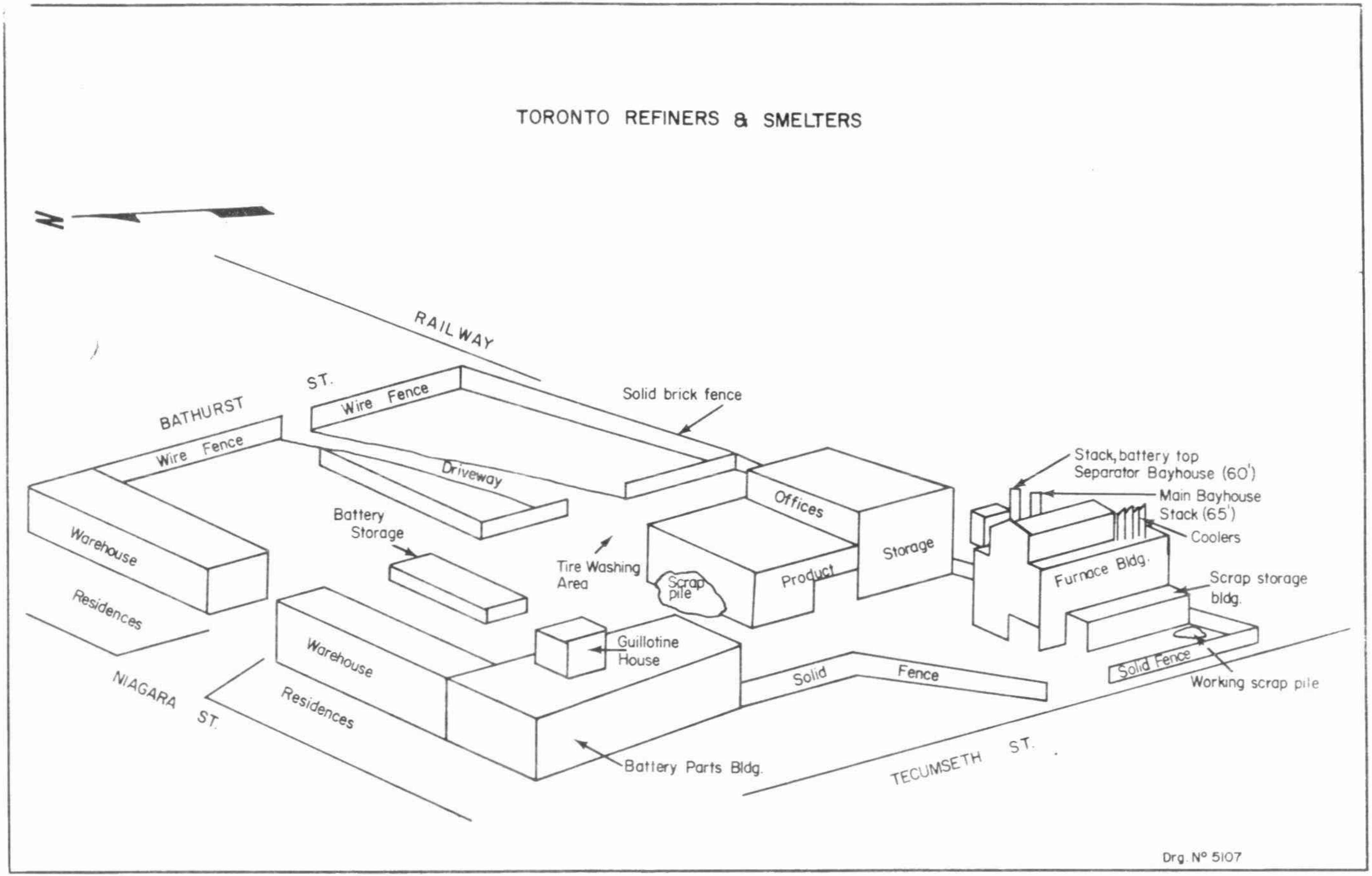
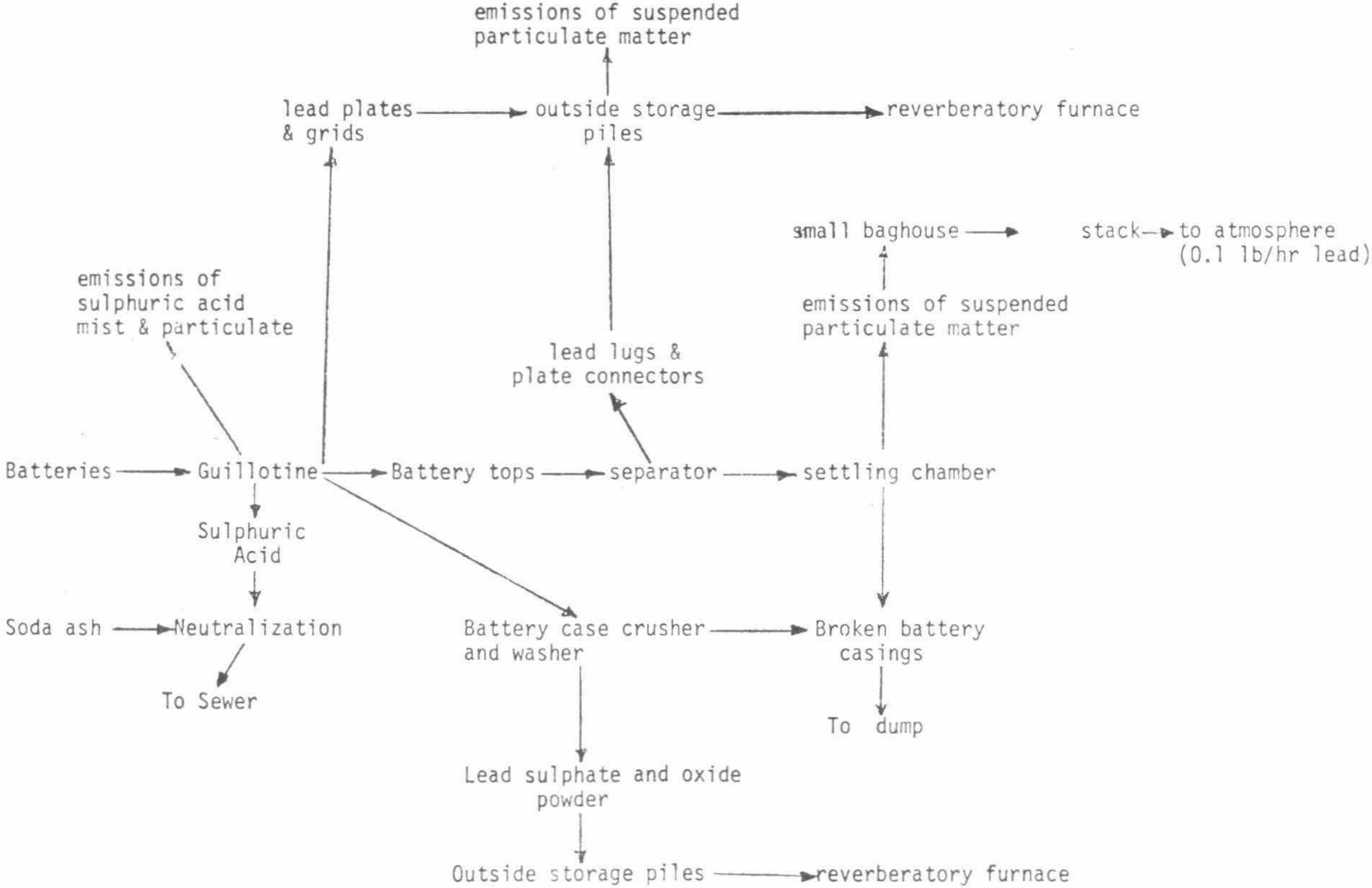


FIGURE - TORONTO REFINERS AND SMELTERS - EMISSION SOURCE LOCATIONS

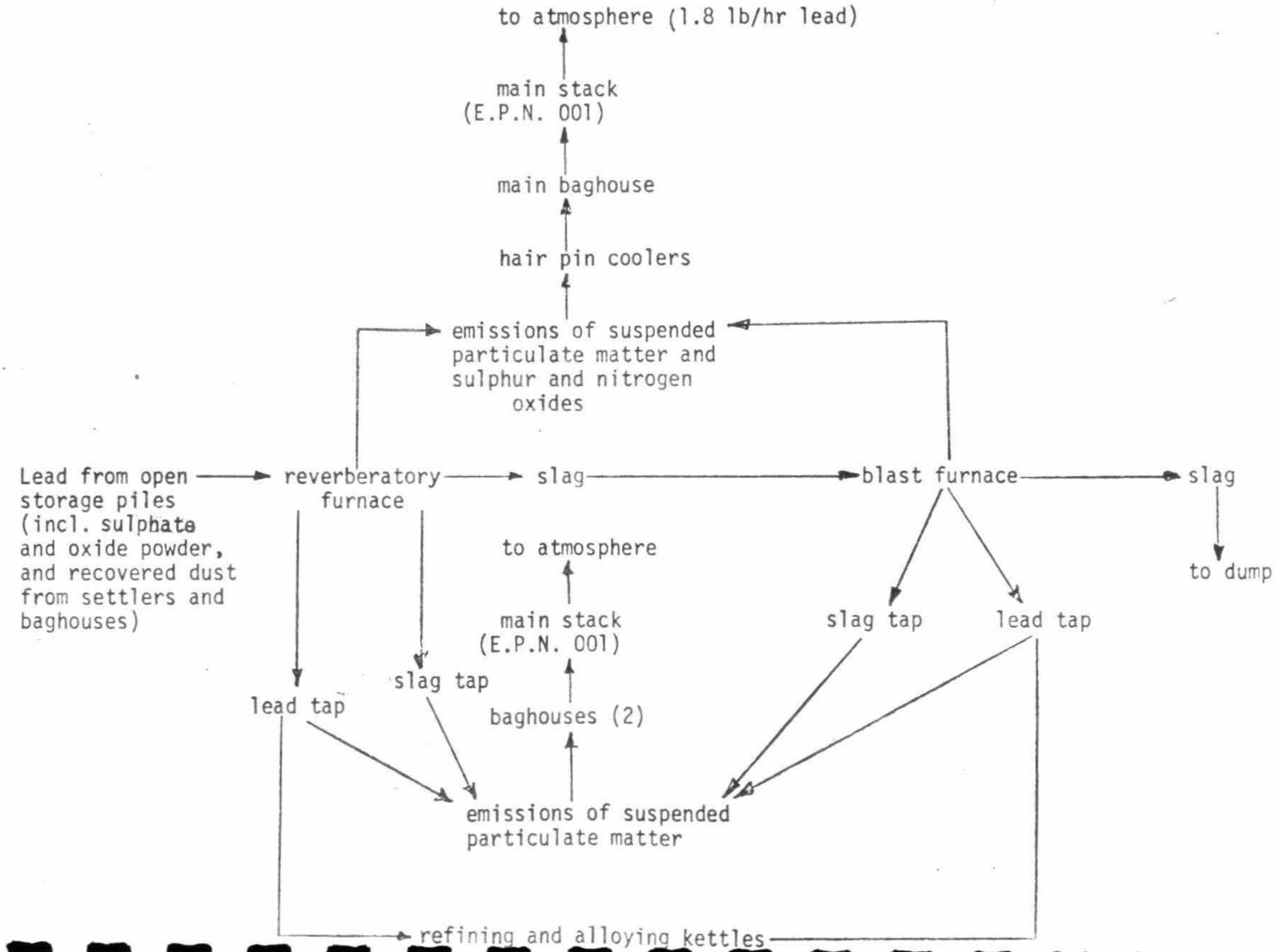
PROCESS FLOW SHEET NO. 1

LEAD RECOVERY OPERATIONS



PROCESS FLOW SHEET NO. 2

SMELTING OPERATIONS



PROCESS FLOW SHEET NO. 3

REFINING & ALLOYING OPERATIONS

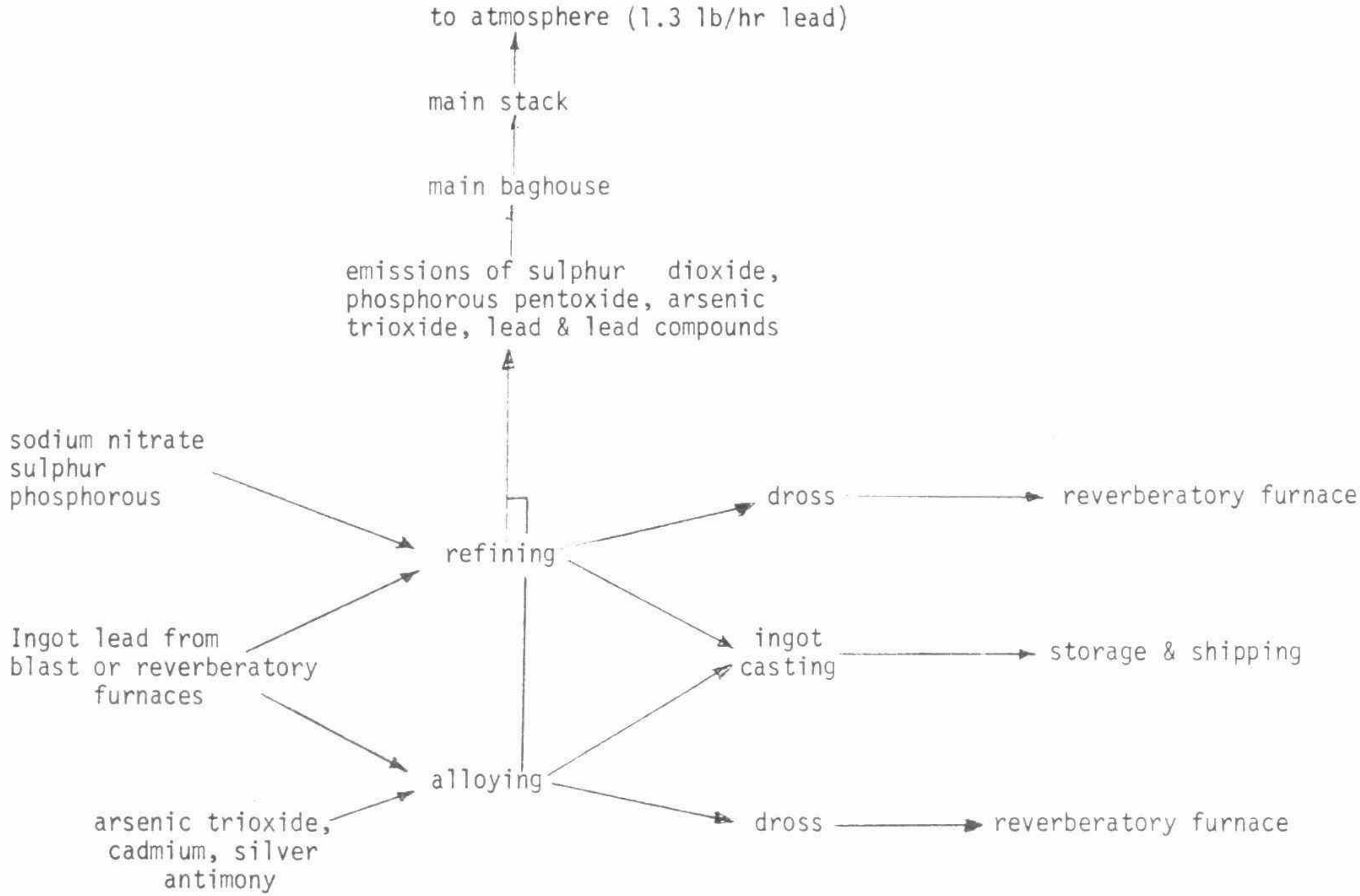


TABLE NO. 6.2-1

SUMMARY OF LEAD EMISSIONS

Pounds per hour emitted

SOURCE	JANUARY 1968	JUNE 1974
Blast Furnace	2.6	1.0
Reverb Furnace	2.3	0.8
Refining and Alloying	5.0	1.3
Battery Top Crusher	Unknown	0.1
Rotary Furnace	0.5	Shut Down
Storage pile and lead separation	Indeterminate	Indeterminate
TOTAL LEAD	10.4	3.2

6.2.3 Summary of Airborne Lead Levels in Vicinity of Toronto Refiners and Smelters

The location of the sampling stations which measure the lead content in suspended particulate matter and in dustfall in vicinity of Toronto Refiners and Smelters are shown in Figure 6.2.3-1.

A summary of the lead data obtained to date in the daily samples of the suspended particulate matter are given in Table 6.2.3-I, and the lead content in the monthly samples of dustfall are provided in Table 6.2.3-II(a) and (b).

The lead levels in suspended particulate matter have frequently exceeded 5 ug/m^3, but only on 4 days have any measurements exceeded 15 ug/m^3 at the two stations in vicinity of the plant. The geometric mean of all past readings exceed the longer term criterion of 2 ug/m^3 at both stations. In the more recent months of March and April of 1974, the criterion was met at Station No. 31018, where measurements were obtained 27 and 28 days respectively.

Correlations of lead levels with hours of wind directions as shown in Figures 6.2.3-2 and 6.2.3-3 indicate significant correlations for winds blowing from the plant property toward the sampling stations. The correlations indicate the plant as being the principle source of the lead concentrations measured at the two locations.

Continuous operation of Station No. 31057 was prohibited by construction on the building on which the sampler was located. The April data for Station No. 31018 did show an improvement over the previous month. The geometric mean was 1.96 ug/m^3, and the maximum reading was 4.40 ug/m^3, thus meeting Ontario's criteria.

The graphs of 28-day and 7-day moving averages of lead concentrations at Station No. 31018, and hours during which winds were in directions from off plant property are given in Figures 6.2.3-4 and 6.2.3-5. The graphs illustrate some air quality improvement during April as compared to previous months.

The major lead problem in vicinity of Toronto Refiners and Smelters has been the content in the dustfall. The measurements at the nearby locations continue to well exceed Ontario's guideline for desirable levels with little or no evidence of any improvement. The concentration of lead in dustfall vary directly with the distance away from the plant. See Figure 6.2.3-6.

Figure 6.2.3-6 illustrates the relationship between the average lead in dustfall levels with distance from Toronto Refiners and Smelters deposit of lead indicates an amount ranging from 7½ to 16 lbs. per day. A reduction in the order of 1/5 to 1/10 of the amount presently emitted would be necessary for Ontario's guidelines to be met.

The size distribution of particles were determined at Station No. 31018, and Station No. 31057, both being in vicinity of the Toronto Refiners and Smelters with Station No. 31018, closer to Bathurst Street and Station No. 31058, closer to the plant. The differences in location reflected differences in distribution with the greater amounts of lead in the larger than 7 um size range occurring at the Station nearest the plant. With distance from the plant, the larger sized particles drop out due to gravity. At both Stations, the distribution differs with that occurring near only traffic generated levels of lead as shown in Figure 6.2.3-7, implying the higher concentrations of lead measured in each size range being due to the emissions from Toronto Refiners.

TABLE 6.2.3-I

TORONTO REFINERS AND SMELTERS
LEAD LEVELS IN SUSPENDED PARTICULATE MATTER

Station No.	Location Name	Location Description	Period Sampled	No. of Days Sampled	Geom. Mean $\mu g/m^3$	Maximum Conc. $\mu g/m^3$	No. of Days Conc. $>5\ \mu g/m^3$	% of Days Conc. $>5\ \mu g/m^3$	No. of Days Conc. $>15\ \mu g/m^3$	% of Days Conc. $>15\ \mu g/m^3$
31018	25 Bathurst St.	250 ft. NNE of Tor. Ref.	19/4/73 to 25/5/74	156	2.23	14	20	13	0	0
31057	Tecumseh St.	120 ft. West of Tor. Ref.	11/4/73 to 21/5/74	113	3.11	25	36	32	4	4

TABLE 6.2.3-II(a)

TOTAL LEAD IN DUSTFALL - TORONTO REFINERS

1 9 7 3 TONS PER SQUARE MILE PER MONTH

STATION	LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
31050	Bathurst-Niagara	3.11	0.97	0.93	Invalid	Spec. Anal.	0.75	0.82	0.68	1.27	1.06	Invalid	1.18	1.19
31051	Niagara St.	0.23	0.20	0.24	0.26	0.43	0.71	0.74	0.64	0.66	0.30	Invalid	0.11	0.41
31053	Cabin D, CNR				0.25	0.37	0.20	0.20	0.26	0.32	Invalid	Invalid	0.57	0.31
31054	Portland/Wellington Streets				Invalid	0.12	0.10	0.12	0.15	0.32	0.11	0.09	0.12	0.14
31055	Tecumseh St. Wood pole 01				5.82	2.49	5.05	2.37	3.57	6.67	3.76	3.47	7.81	4.55
31056	Wellington/ Niagara St.				0.10	0.08	0.36	0.15	0.18	0.12	Invalid	Invalid	0.54	0.22

TABLE 6.2.3-II(b)

1974 LEAD IN DUSTFALL RESULTS - TORONTO REFINERS

TONS PER SQUARE MILE PER MONTH

STATION NO.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
31050	.89*	.87	.58	1.13	.84							
31051	.19*	.38	.24	.44	.24							
31053	.13	.50	.84	.26	.32							
31054	.11	.11	.11	.11	.11							
31055	5.19	10.11	5.12	4.60	3.94							
31056	.16	.21	.15	.30	.15							
31074	1.41*	.14*	.75	.94	.64							
31075	.07*	.05*	.09	.13	.16							

* INSOLUBLE lead only

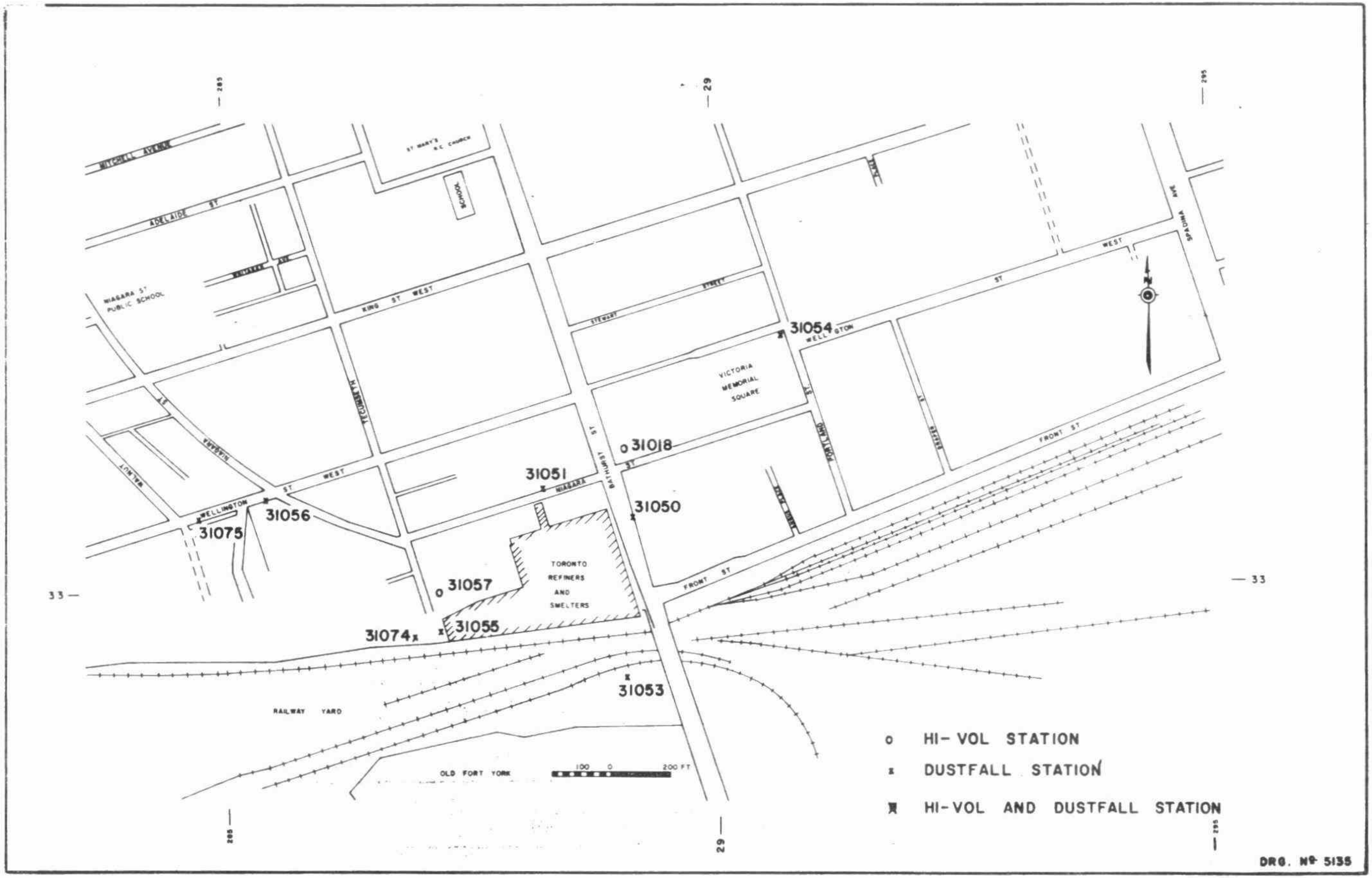
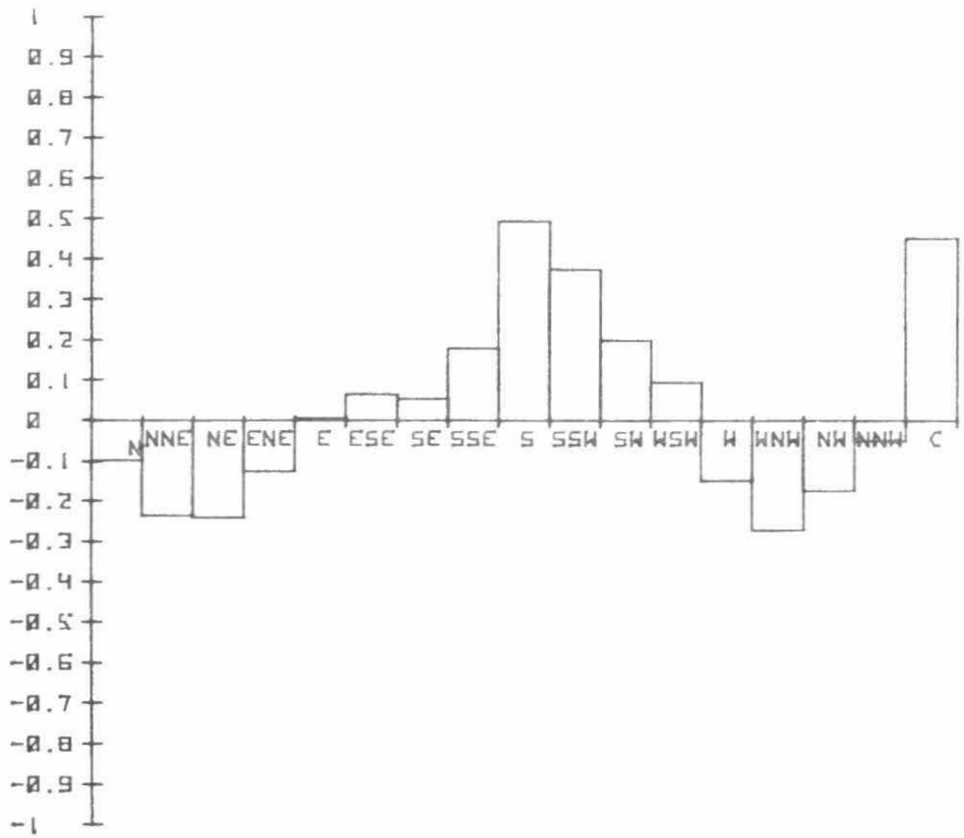


FIG. 6.2.3-1 – LOCATION OF AIR MONITORING STATIONS NEAR TORONTO REFINERS AND SMELTERS.

FIG. 6.2.3-2 STATION NO 31018 FROM 19/4/73 TO 31/3/74 116 READINGS

CORRELATION COEFFICIENTS OF PARTICULATE WITH WIND DIRECTION



CORRELATION COEFFICIENTS OF LEAD WITH WIND DIRECTION

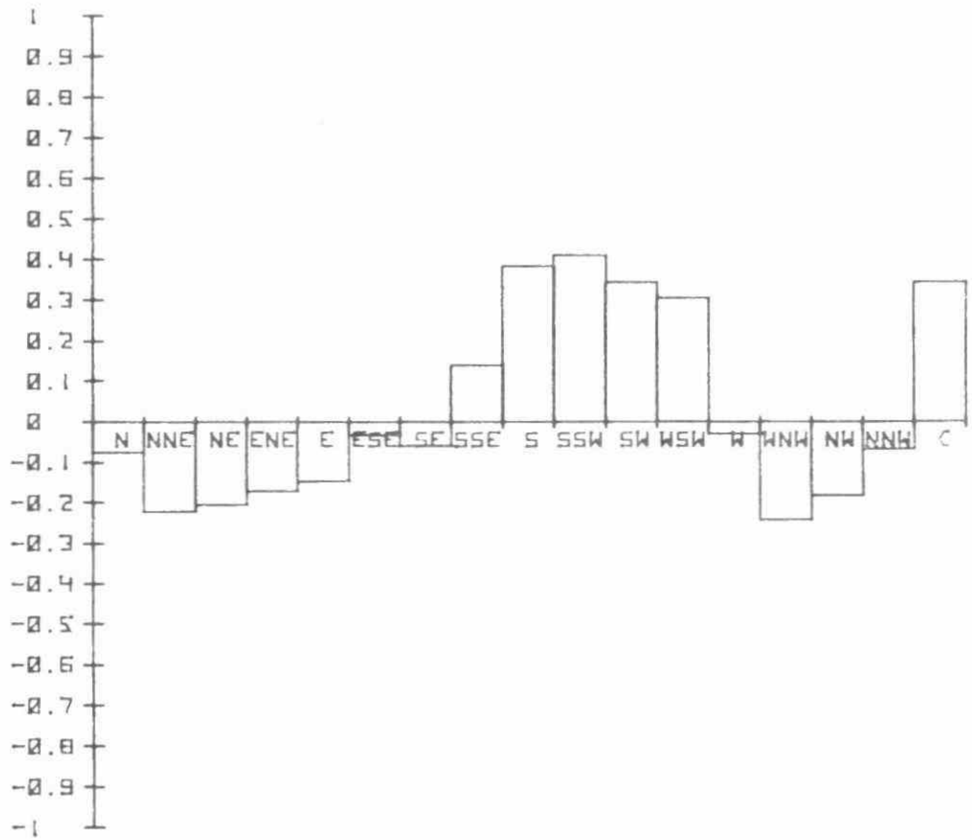


FIG. 6.2.3-3 STATION NO 31057 FROM 11/4/73 TO 27/3/74 96 READINGS

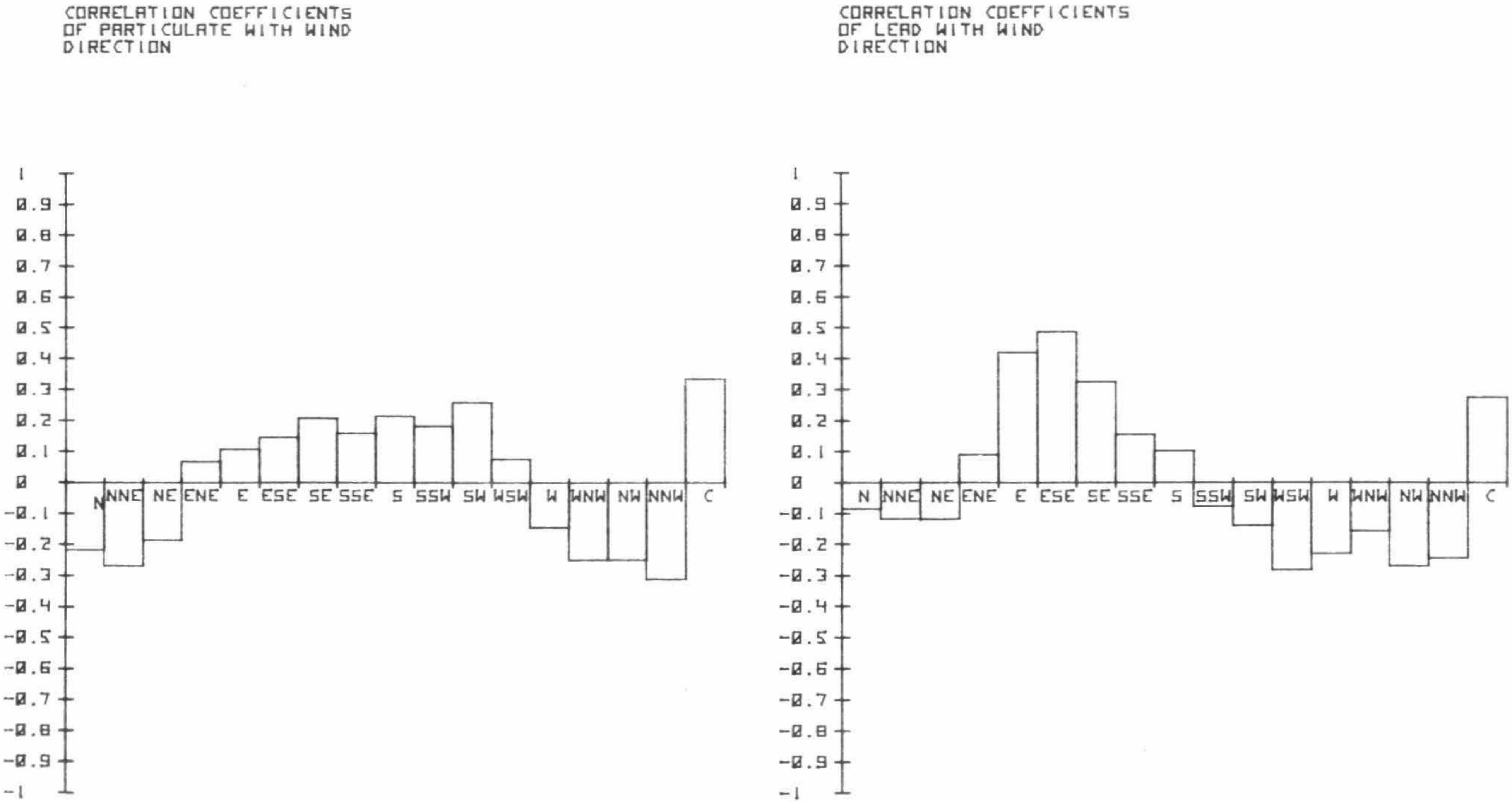
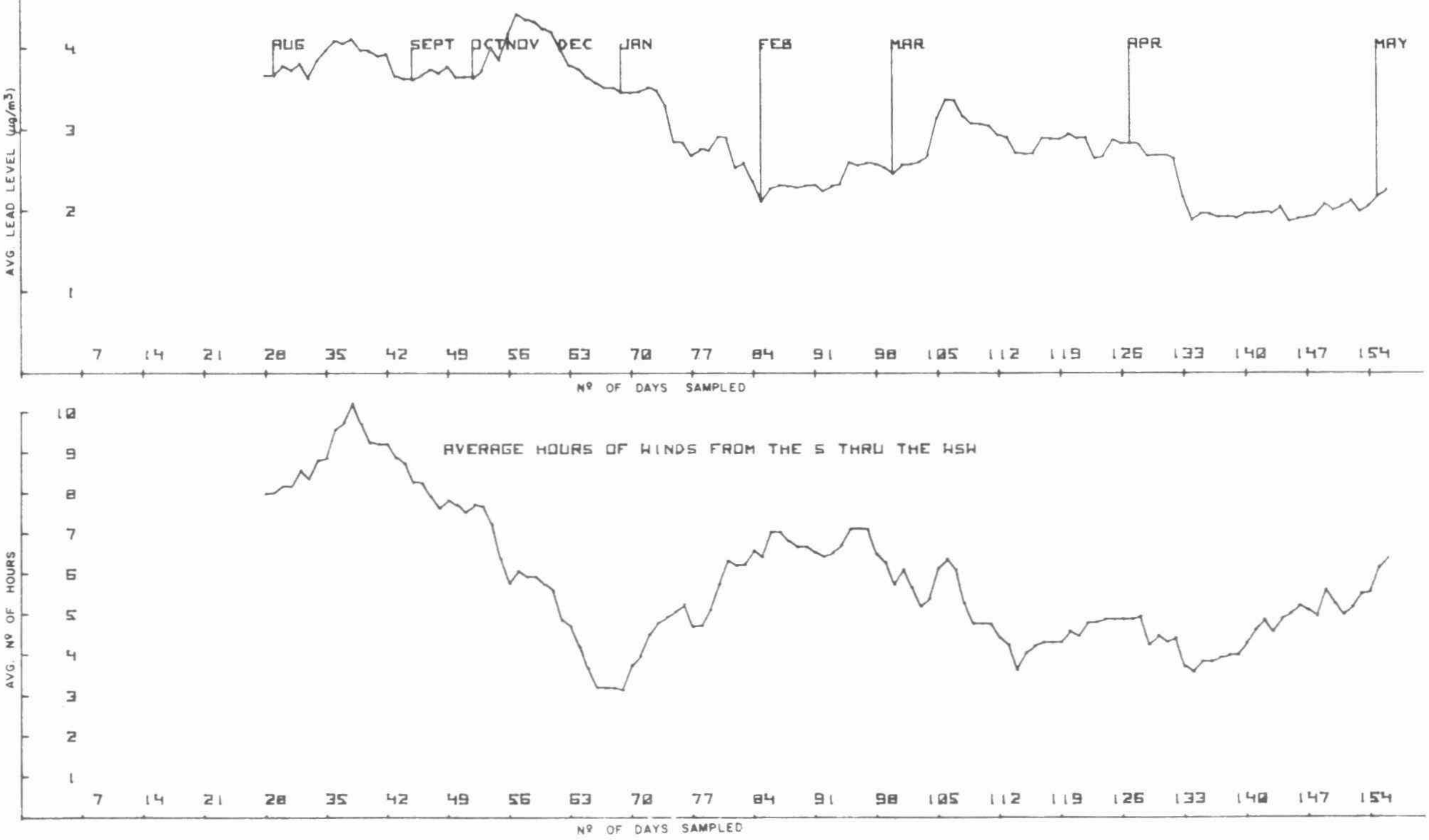


FIG. 6.2. 3-4 TORONTO REFINERS STATION NO 31010 - 28 DAY MOVING AVERAGES



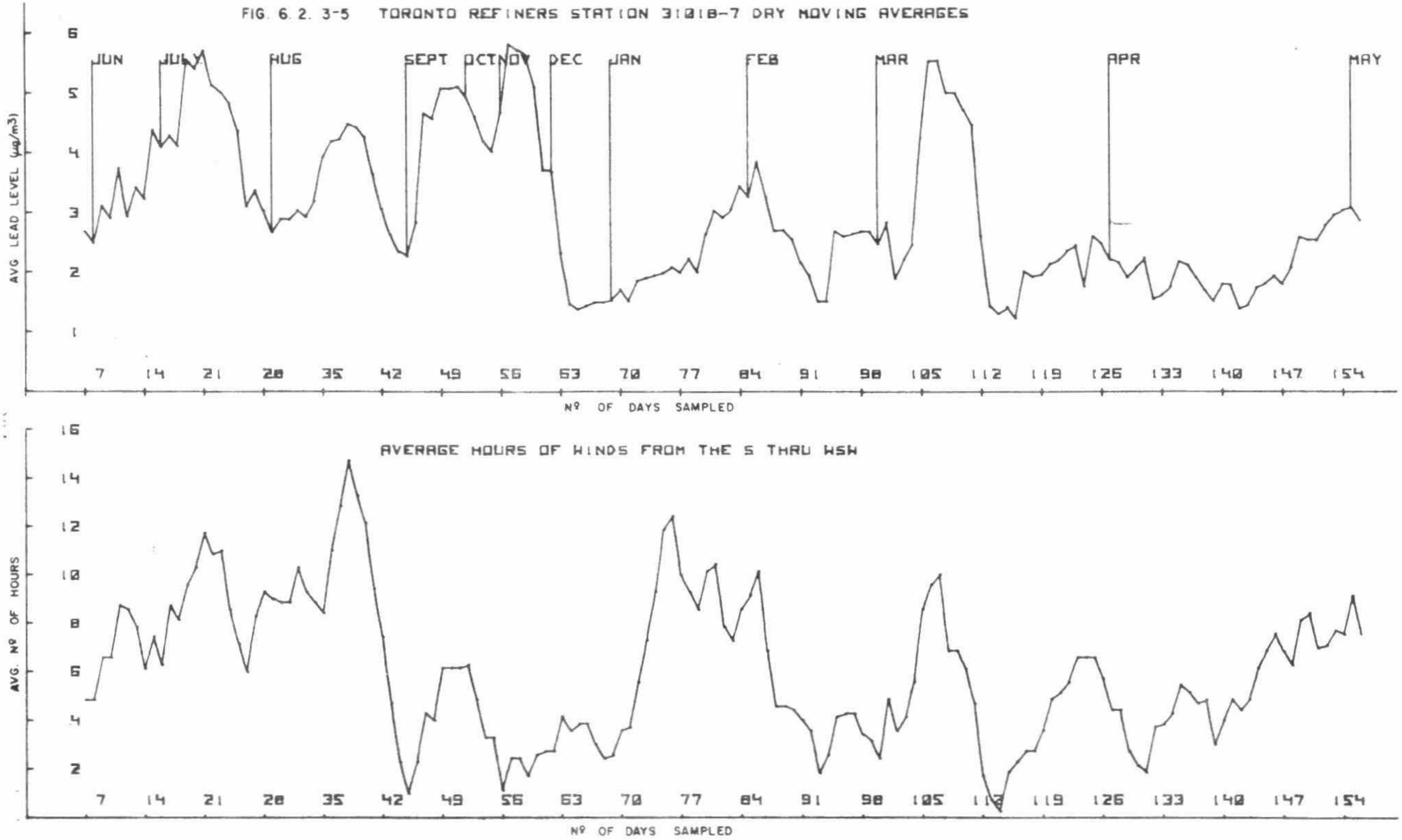


FIG. 6.2.3-5 TORONTO REFINERS STATION 31018-7 DAY MOVING AVERAGES

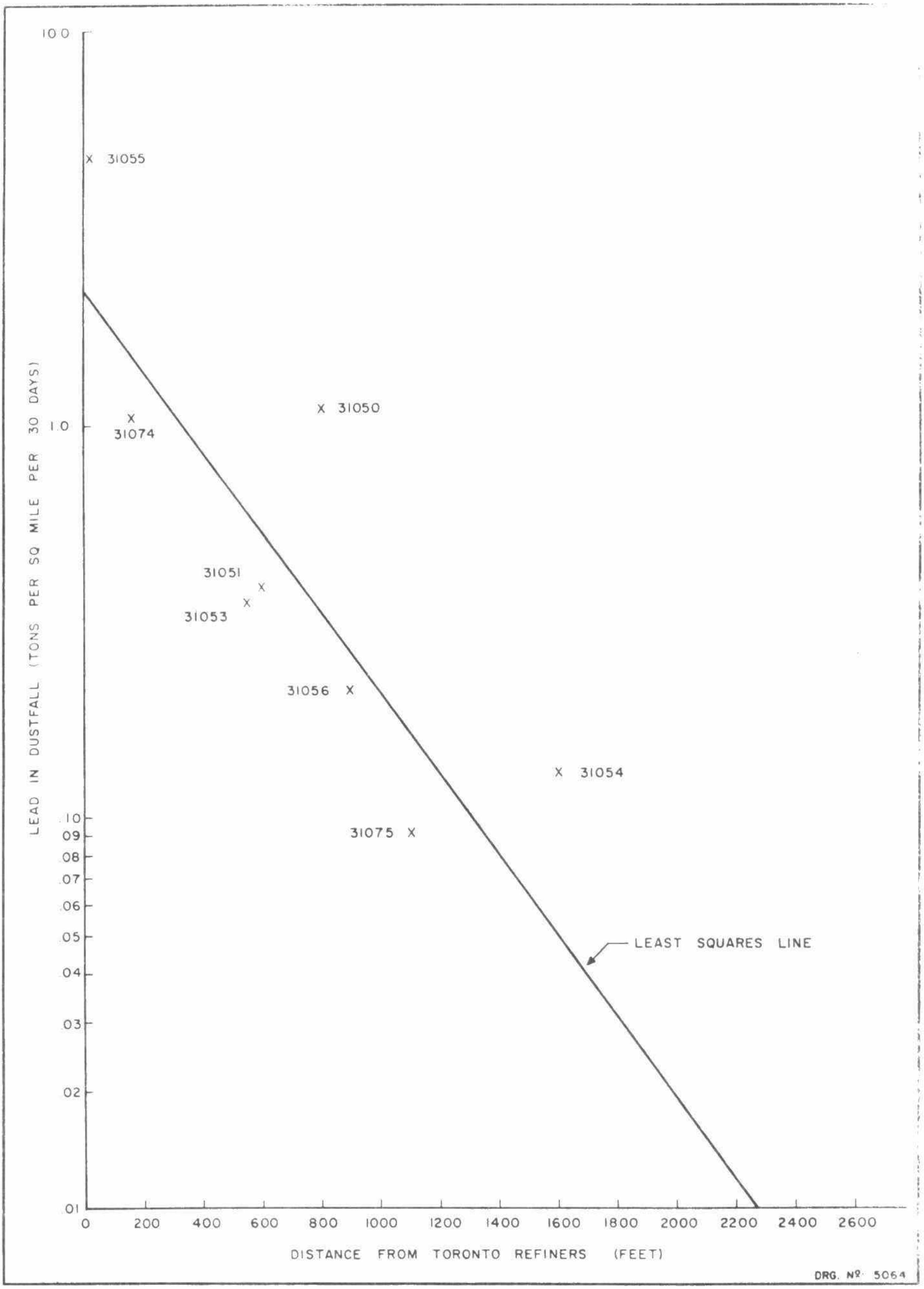


FIGURE 6. 2. 3-6 - AVERAGE LEAD IN DUSTFALL VS. DISTANCE FROM TORONTO REFINERS

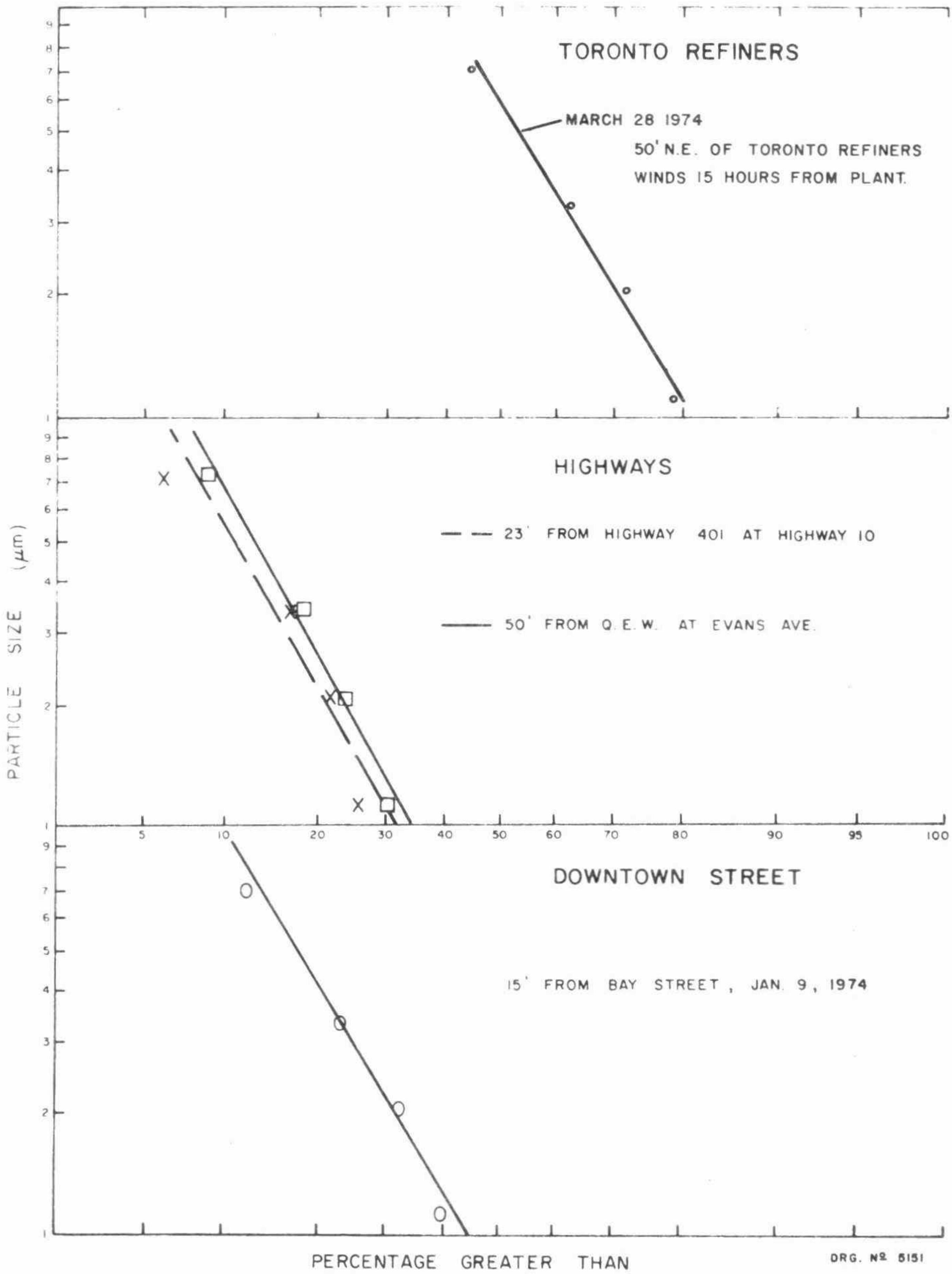


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FIG. 6.2.3-7 TYPICAL PARTICLE SIZE DISTRIBUTION FOR LEAD NEAR STREETS, HIGHWAYS, & TORONTO REFINERS.

6.2.4 Summary of Lead Levels in Soil and Vegetation in the Vicinity of Toronto Refiners and Smelters, 28 Bathurst St., Toronto

The key conclusions of phytotoxicology assessment surveys conducted in the vicinity of Toronto Refiners and Smelters in 1972 and 1973 are:

1) A survey conducted in July 1972 at 10 locations in the vicinity of Toronto Refiners and Smelters demonstrated exceedingly high lead contents in surface soil (8,250 ppm) 100 feet east and in not washed foliage (6800 ppm) 20 feet north of the company. The not washed foliar samples possessed two to three times more lead than found in washed foliar samples. Lead levels in soil and vegetation decreased with distance to the north from the company.

2) An expanded soil survey was conducted in March 1973 to delineate the extent of soil contamination in the vicinity of Toronto Refiners. The contaminated area (over 600 ppm in surface soil) extended to a distance of approximately 1500 feet east and west and 1200 feet north of the company. Statistically significant decreases in lead content in soil were shown with increasing distances to the east, northeast, north and west of the company.

3) The July 1972 survey was repeated one year later in which time the battery crusher was inoperative, and the results showed a twenty-fold reduction in lead levels in tree foliage immediately north of the company.

4) In a fresh fruit and vegetable survey conducted in July 1973, none of 23 fresh fruit collections exceeded the Federal Health standard of 7 ppm lead, whereas six of 38 fresh vegetable collections exceeded the Federal standard of 2 ppm. Interpretation of all the analyses results indicated that the six excessive lead levels in fresh vegetables were due to surface contamination of soil.

5) A dust sampling survey conducted in August 1973 showed that street dust collected near the refinery did not contain lead concentrations in excess of those found in dust on other streets in the City of Toronto. However, lead levels in undisturbed dust near the refinery were excessive when compared to similar dust samples collected at a distance from the refinery. The area of residual soil lead contamination closely approximated the area possessing high levels of lead in undisturbed dust.

6) There was a general increase in lead levels in vegetation in the vicinity of the refinery during the period July 4 to September 19, 1973. The greatest increases were found immediately to the east, south and west of the refinery. Improvements in lead levels to the north of the company reflected relocations of operations on company property.

7) A soil survey to indicate depth and extent of lead contamination in the vicinity of Toronto Refiners was conducted in November 1973. Soil contamination isopleths were drawn on a map showing the areas north of the company possessing over 500 ppm lead in soil to various depths.

Description of these surveys follow, which include sampling locations, analyses results and their interpretation.

6.2.4.1 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - July 24, 26, 1972

Description of Investigation

A soil and vegetation survey was conducted at 10 locations in the vicinity of Toronto Refiners and Smelters (Figure 1). Excessive levels of lead were detected in vegetation at distances up to 600 feet north and west, 1000 feet east, and greater than 150 feet south of the plant, with extremely high levels being detected immediately to the north and east of the company property (see Table 1). Severe contamination of soil also was found to occur within this area. A comparison of the lead analyses for not washed and washed vegetation indicated a ratio of 2-3: 1, suggesting considerable surface lead contamination.

TABLE I

Chemical Analysis Results for Lead in Soil and Vegetation Collected in the Vicinity of Toronto Refiners and Smelters on July 24 and 26, 1972

Station No.	Distance and Direction from Source	Lead Content (parts per million-dry weight)		
		Ailanthus		Surface Soil
		NW*	W**	
1	150' S	246	76	4000
2	100' E	710	245	8250
3	400' ENE	291	96	575
5	500' NNE	330	71	2320
4	1200' NE	86	45	890
6	20' N	6800	2200	2350
7	200' N	530	280	1400
8	600' N	130	50	940
9	100 'W	295	80	2250
10	500' W	317	62	4000
Control	1.8 mile NE	48	30	365

*NW - analyzed as collected

**W - washed prior to analysis

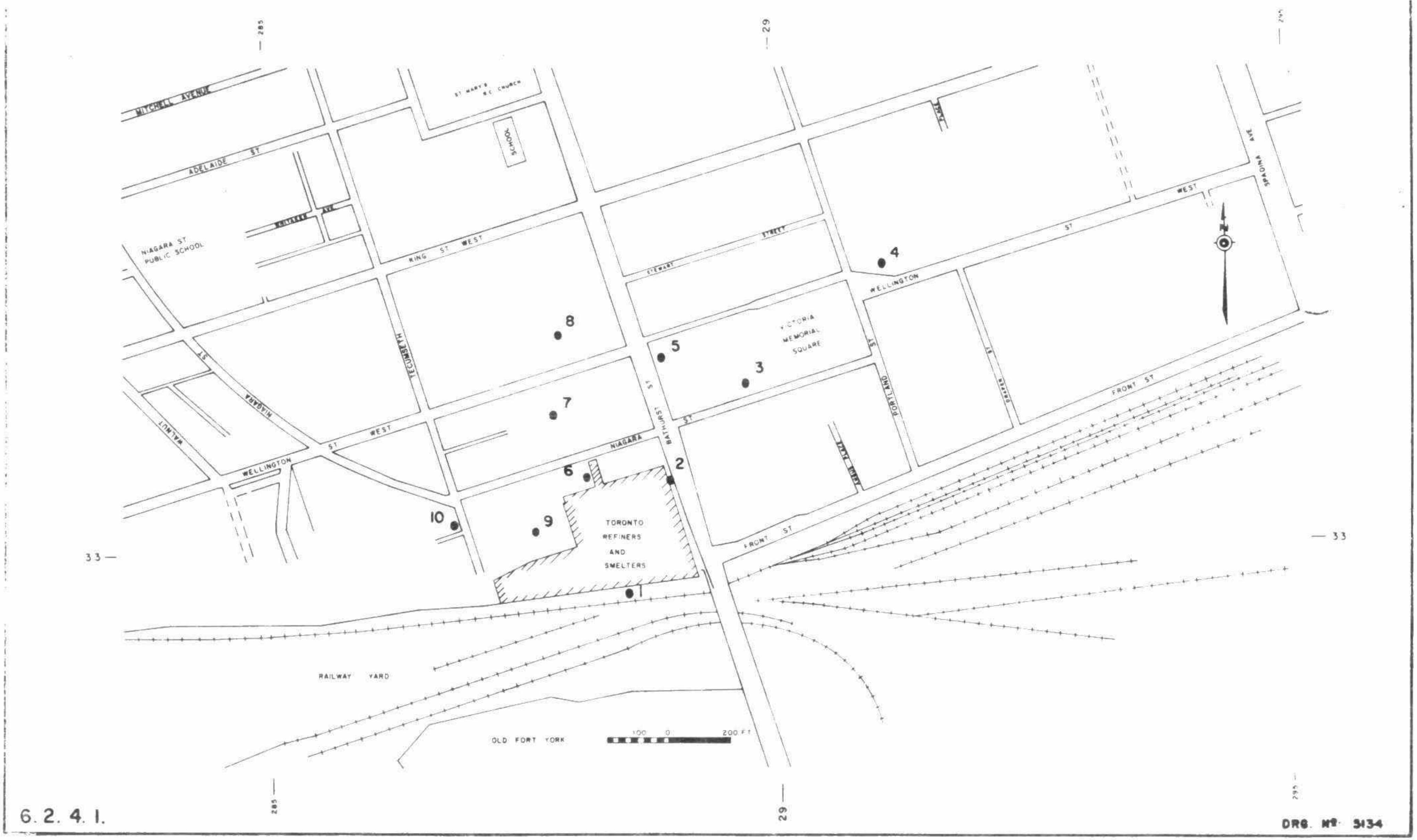


FIG. I - VEGETATION AND SOIL SAMPLING LOCATIONS NEAR TORONTO REFINERS AND SMELTERS JULY 24 AND 26, 1972.

6.2.4.2 Phytotoxicology Assessment Survey For Lead in Soil
March 13, 1973

Description of Investigation

An extensive soil sampling survey was conducted in the vicinity of the Toronto Refiners and Smelters plant. Samples of soil from the 0-2 and 2-4 inch depths were collected at increasing distances to the ENE, N. NW and W and from a control location to the NE.

Observations and Results

The lead analyses results for the soil sampling survey are shown in the attached table. Soil lead levels significantly above normal for an urban area were found from just beyond Draper Street on the east, Stewart and King Streets on the west (see attached map). This contaminated zone comprised an area approximately 1500 feet to the east and west, and 1200 feet to the north of the source, or approximately 0.2 square miles. The extremely high levels of lead detected in the 0-2 inch layer confirm the airborne nature of the contamination.

The correlation between the lead content of the 0-2 and 2-4 depths and sampling distance from the source is shown below:

Direction from Source	Correlation Between Lead Content and Sampling Distance 0-Inch Soil Depth	2-4 Inch Soil Depth
E	-0.90*	-0.90*
NE	-0.99**	-0.95*
N	-0.93*	-0.95*
NW	-0.90*	-0.75

** significant at 1% level
[illegible] significant at [illegible] level

With one exception, the lead content of 0-2 and 2-4 inch soil layers decreased significantly with increasing distance to the E, NE, N and NW of the plant.

TABLE 1

Lead Content of Soils Collected in the Vicinity
of Toronto Refiners and Smelters

March 13, 1973

Station No	Distance from Source	Lead Content (ppm dry weight) 0 - 2"	2 - 4"
1	200' E	10,000	7,600
2	750' E	813	495
3	1,500' E	1,375	800
4	2,350' E	590	388
5	600' NE	2,300	1,175
6	1,000' NE	1,325	1,025
7	1,500' NE	615	728
8	50' N	11,950	5,500
9	300'NN	1,400	1,075
10	850' N	1,300	875
11	1,200' N	225	238
12	350' NW	1,475	630
13	725' NW	850	510
14	1,250' NW	238	288
15	1,575' NW	40	15
16	1,100' W	623	460
17	2,250' W	330	85
18	2.5 miles NE	320	288
(Control)			

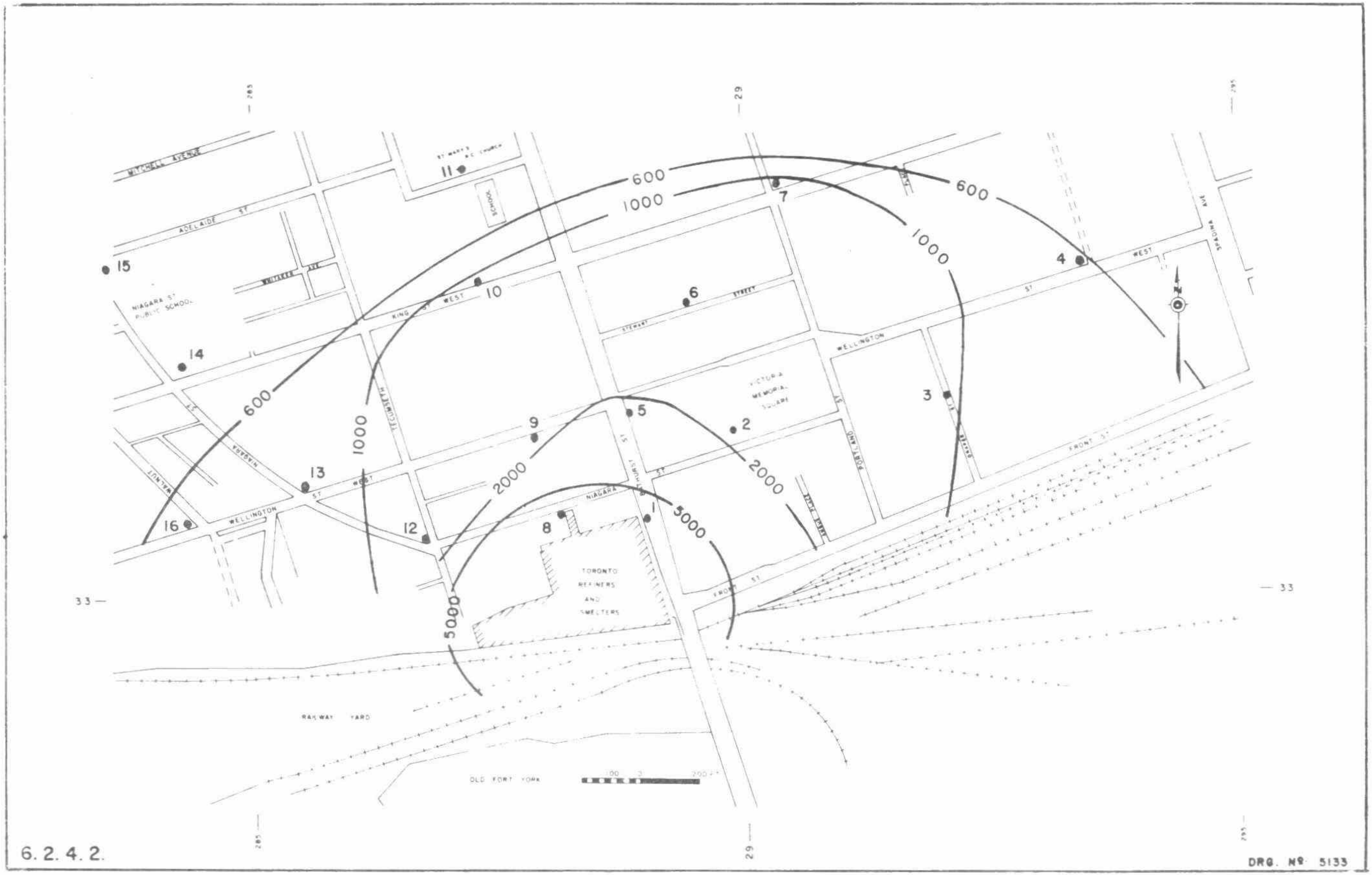


FIG. I - ZONES OF LEAD CONTAMINATION (IN ppm) IN SURFACE SOIL (0-2" DEPTH) NEAR TORONTO REFINERS AND SMELTERS, MARCH 13, 1973.

6.2.4.3 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - July 4, 1973

Description of Investigation

This survey which consisted of sampling soil and Ailanthus foliage for lead analysis from the same locations in the vicinity of Toronto Refiners as on July 24, 1972, was conducted just prior to the rescinding of the AMB Stop Order in early July 1973.

Observations and Results

The lead content of the soil and vegetation is shown in Table 1. Shown also are the corresponding lead analyses results for the 1972 samples.

Elevated levels of lead were detected in the washed foliage of Ailanthus trees growing in the area bounded by Wellington Street on the north, Tecumseth Street on the west and Bathurst Street on the east, with high levels being detected in the immediate vicinity of the plant. The lead content of the soil in this area also was extremely high, with the area of contamination extending to the boundaries that were previously established in the March 1973 soil survey.

Since lead is tenaciously held by soils, the levels in soil were relatively unchanged from 1972 to 1973. The variations in the lead levels were due to the heterogenous nature of soil, and to the variabilities encountered in sampling. In contrast, it is apparent from these results that the lead content of the deciduous Ailanthus foliage

generally was much lower in July 1973 than was found in July 1972. The nature and extent of this reduction is shown in Table 2. Samples collected to the north and northeast of the plant contained levels of lead that ranged from 32 to 96% lower than in 1972. In each of these directions the greatest reduction in lead content was detected close to the plant and the size of the reduction decreased with increasing distance from the source. These figures reflect a decrease in airborne lead in the area over the one-year period.

TABLE I

Lead Content of Soil and Vegetation

Vicinity of Toronto Refiners and Smelters

July 24, 1972 and July 4, 1973

Station No.	Distance & Direction from Source	Lead Content (ppm - dry weight)					
		Ailanthus				Soil(0-4 Average)	
		July 24/72		July 4/ 73		July 24/72	July 4/73
		NW	W	NW	W		
1	150' S	246	76	155	86	4000	5625
2	100' E	710	245	125	52	8250	20590
3	400' ENE	291	96	59	22	575	612
5	500' NNE	330	71	98	48	2320	587
4	1200' NE	86	45	44	24	890	565
6	20' N	6800	2200	300	120	2350	6500
7	200' N	530	280	126	60	1400	877
8	600' N	130	50	48	22	940	375
9	100' W	295	80	650	220	2250	2187
10	500' W	317	62	260	110	4000	4500
Control	1.8 mile NE	48	30	34	11	365	212

TABLE 2

Percent Reduction in Lead Content of Ailanthus Foliage
During Period of Stop-Order
(Collections Made July 24,1972 and July 4, 1973)

Station No.	Distance and Direction from Smelter	Percent Reduction in Lead Content Ailanthus Foliage	
		Not Washed	Washed
1	150' S	37	+ 13
2	100' E	82	79
3	400' ENE	80	77
5	500' NNE	70	32
4	1200' NE	49	47
6	20' N	96	95
7	200' N	76	79
8	600' N	63	56
9	100' W	+ 120	+ 175
10	500' W	18	+ 77

\+ %increase in lead content
Lead content in ppm - dry weight

6.2.4.4 Phytotoxicology Assessment Survey for Lead in Fruit and Vegetables - July 30 - 31, 1973

Description of Investigation

Samples of fresh fruit, fresh vegetables, leaves, stems, roots and soil were collected for lead analysis from 27 locations within a 1500 foot radius of the company. The sampling was requested by the Toronto Board of Health and was designed to determine if home grown fruit and vegetables were safe for human consumption.

Observations and Results

Table 1 lists the average lead contents of fruit, lettuce, other leafy crops, beans, stem and root crops, and soil in which these crops were growing. Twenty-three fresh fruit samples were collected, most of which were tomatoes. All samples had lead levels well below 7 ppm, which is the maximum acceptable level for lead in fresh washed fruit, as set by the Federal Health Protection Branch. The highest lead level among fruit samples was 1.1 ppm. Of the 38 fresh vegetable samples collected, six samples exceeded the Health Protection Branch maximum acceptable limit for lead in fresh washed vegetables of 2 ppm. Four of these samples were lettuce leaves and two were root crops, horseradish and beets. It is likely that high lead levels in these samples were due to surface contamination by soil, because garden soil in this area averaged 672 ppm in the upper two inches. However, this lead in the soil does not readily enter plants and except for surface contamination, fresh fruits and vegetables collected around Toronto Refiners were safe to eat.

TABLE 1 - Average lead levels in fresh washed fruit and vegetables, and in garden soil collected near Toronto Refiner and Smelters

Sample	Lead Content, PPM	
	Average	Range
Fruit	0.43	0.2 - 1.1
Lettuce	3.50	1.1 - 14.5
Leafy vegetables	1.24	0.4 - 1.9
Beans (whole pods)	0.77	0.6 - 1.0
Stem crops	1.00	0.4 - 1.7
Root crops	1.01	0.6 - 2.1
Garden soil 0-2 inches	672	198 - 1260
2-4 inches	681	288 - 1650

6.2.4.5 Phytotoxicology Assessment Survey for Lead in Dust August 20 - 21, 1973

Description of Investigation

This survey was designed to determine the extent to which dust on streets and in undisturbed locations contributed to lead contamination in the Toronto Refiners and Smelters area.

The sampling locations were selected to correspond with a soil sampling survey which was conducted on March 13, 1973. Accordingly, sixteen sites located at increasing distances to the east, northeast, north, northwest and west of the plant were sampled. Control samples were collected at 0.6 and 3 miles north and 1 mile north northwest. The surfaces sampled can be grouped into two main categories:

1. paved streets
2. other surfaces
   - (excludes all surfaces subject to normal vehicular movement)
   - window ledges
   - sewer covers (metal)
   - asphalt (driveways, street shoulders, private parking lots and playgrounds)

A sample of dust from the street was collected at each site. Sampling from other surfaces varied according to the site characteristics.

Observations and Results

The percent of lead in the dust samples collected from streets and other surfaces is shown in Table 1. Shown also for comparative purposes is the lead content of the corresponding samples of soil (0-2 inch layer) which were collected five months earlier.

(i) Dust from Street Surfaces

The percentage of lead in dust collected on street surfaces ranged from 0.31 to 1.10%. With one exception, the lead content of dust collected from streets close to the source was similar to that of dust collected from streets in control areas. The exception was the elevated level of 1.1% lead in dust collected from Bathurst Street at Station 1, immediately east of the source.

A statistical comparison of the street dust results with the lead content of soil samples collected in March yielded a non-significant "r" value of 0.37.

(ii) Dust from Other Surfaces

The composition of dust collected from surfaces other than paved streets, ranged from 0.20 to 7.72%, with the highest levels being detected near the company. Lower levels generally were detected at increasing distances in each direction from the company. A statistical comparison of these results with the corresponding soil analyses, revealed highly significant (1% level) "r" values of 0.77 and 0.90 respectively for the 0-2 and 2-4 inch soil layers. The area of lead contamination, based on (i) the dust samples and (ii) the soil samples is shown within the areas on the attached map. It is readily apparent that these two methods of defining the lead contamination problem have yielded remarkably similar findings.

In an effort to check the validity of these findings, comparisons were madebbetween the lead content of the dust samples at Stations 1 and 12 and corresponding lead values from hi-volume samplers operating at these locations.

Sampling Location	Average % Lead in Hi-Volume Samples Apr-Aug 1973	Average % Lead in Dust Samples Aug 20, 1973
Station 1 (Hi Vol 31018) Bathurst St.	2.05	2.02
Station 12 (Hi Vol 31057) Tecumseh St.	2.68	1.85

* values shown are extrapolated to correspond with location of hi-volume sampler

** values shown are from surfaces not travelled by vehicular traffic

The percentage composition of lead in the two types of samples was found to be similar at the two locations.

TABLE I

Lead Content of Dust and Soil Collected in the Vicinity of Toronto Refiners and Smelters, Toronto

Station No.	Distance from Source	Lead Content of Dust (%)		Lead Content of Soil (ppm) - dry weight
		Street Surfaces	Other Surfaces	(0-2 inch layer)
1	200' E	1.10 (Bathurst)	7.72, 1.81	10 000
2	750' E	0.61 (Niagara)	1.07	813
3	1500' E	0.45 (Wellington)	0.82	1 375
4	2350' E	0.49 (Wellington)	-	590
5	600' NE	0.50 (Bathurst)	0.40	2 300
6	1000' NE	0.60 (Stewart)	0.54	1 325
7	1500' N	0.52 (Portland)	0.24	615
8	50' N	0.31 (Niagara)	2.23, 1.47	11 950
9	300' N	0.55 (Wellington)	0.97	1 400
10	850' N	0.46 (King)	-	1 300
11	1200' NW	0.38 (Adelaide)	0.24	225
12	350' NW	0.67 (Tecumseth)	1.47	1 475
13	725' NW	0.46 (Wellington	0.67	850
14	1250' NW	0.31 (King)	-	238
15	1575' NW	0.41 (Niagara)	0.32	40
16	1100' W	0.37 (Walnut)	0.47	623
Controls	0.6 mi N	0.42 (Bathurst)	0.48	-
	3.0 mi N	0.78 (Bathurst)	0.43	-
	1.0 mi NNW	0.34 (Dovercourt)	0.20	-
	2.5 mi NW	- -	-	320

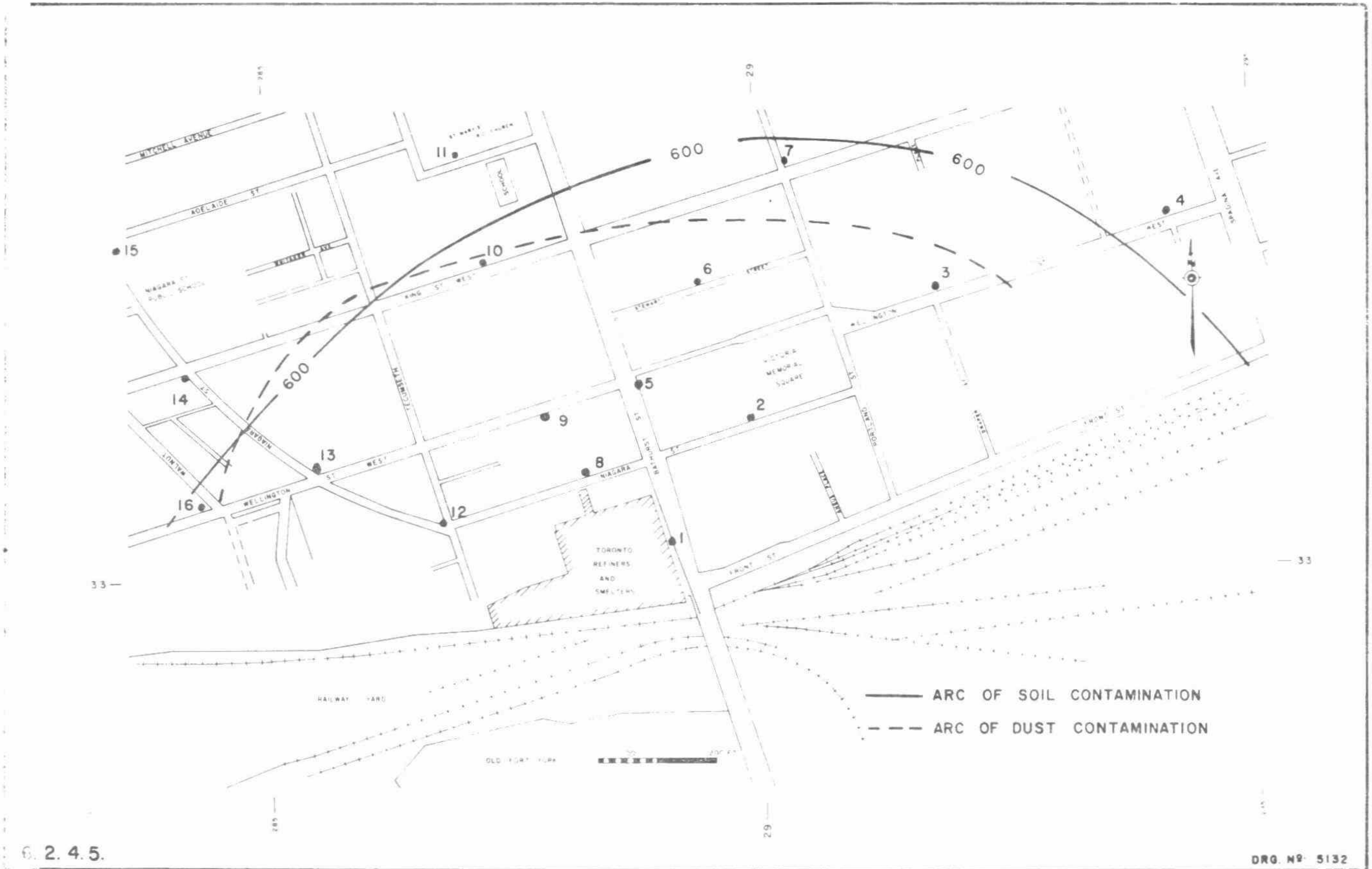


FIG. I - LEAD CONTAMINATION OF SOIL AND DUST NEAR TORONTO REFINERS AND SMELTERS
AUGUST, 1973

6.2.4.6 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - September 19, 1973

Description of Investigation

This survey was conducted approximately 10 weeks following the cessation of the AMB Stop Order on the battery crusher at Toronto Refiners and Smelters.

Samples of Ailanthus foliage and soil from the 0-2 and 2-4 inch layers were collected for lead analysis from 10 previously established sampling locations (July 4, 1973, July 24, 1972).

Observations and Results

The lead content of the soil and vegetation samples is shown in Table 1. Excessive levels of lead were present in vegetation in an area extending to the northeast of the company as far as the intersection of Portland and Wellington Streets. The area immediately north of the company was much less severely affected than in previous surveys with the lead content of vegetation just approaching excessive levels. Excessive levels also were present to the immediate south and to the west as far as Tecumseth Street. Little or no change was detected in the severity of soil contamination when compared to previous surveys. The size of the area of soil contamination also remained unchanged from the boundaries established during the March 1973 survey.

For comparative purposes, the lead contents (not washed) of Ailanthus foliage collected from the 10 permanent sampling sites in July and September, 1973 and July 1972 are shown in Table 2.

The use of the September 1973 lead levels in vegetation as an indication of the effectiveness of the controls that were installed on the battery crusher prior to its start-up in July 1973 depends on an understanding of the exposure periods. The lead detected on the foliage in July 1973 was deposited over an approximate 5 week period of the growing season during which time the crusher was inoperative. The lead detected in September was deposited on the foliage over the same 5 week period and for an additional 10 week period during which time the crusher was operating. Because of these differences, a simple comparison of the two sampling dates is of little value. However, if it is assumed that lead deposited on vegetation during the first five weeks of the growing season would continue to have been deposited at the same rate for the next 10 weeks, it is possible to predict the lead levels in September, had the battery crusher remained closed all summer. A comparison of these "predicted lead levels" with the actual September levels then would yield the approximate contribution of the "controlled" crusher to the background lead emissions from other sources within the plant. The actual and predicted levels are shown in Table 3. In only one case (Station #3) was the actual level much higher than the predicted figure. At the remainder of the stations, the actual lead content either was less than or similar to the predicted level. These comparisons indicate that the higher lead levels detected in September have resulted from ongoing lead emissions from other sources in and around the plant and that the lead emission controls installed on the battery crusher appear to be effective.

TABLE I

Lead Content of Soil and Vegetation

Vicinity of Toronto Refiners and Smelters

September 19, 1973

Station No.	Distance and Direction from Source	Lead Content (ppm-dry weight)			
		Ailanthus Foliage		Soil	
		NW	W	0-2"	2-4"
1	150' S	339	378	4850	1530
2	100' E	308	231	4050	1980
3	400' ENE	249	74	650	448
5	500' NNE	174	123	625	675
4	1200' NE	128	81	343	278
6	50' N	168	74	2950	4130
7	200' N	68	47	1080	718
8	600' N	151	89	775	800
9	100' W	290	200	1730	670
10	500' W	370	200	1200	1130
Control	1.8 mile NE	48	20	403	298

NW - not washed

W - washed

TABLE 2

Lead Content of Ailanthus Foliage Collected
in the Vicinity of Toronto Refiners and Smelters
July 24,1972 - July 4, 1973 - September 19, 1973

Station No.	Distance and Direction from Source	Lead Content (ppm - dry weight) Ailanthus foliage (not washed)		
		July 24/72	July 4 /73	Sept. 19/73
1.	150' S	246	155	339
2	100' E	710	125	308
3	400' ENE	291	59	249
5	500' NNE	330	98	174
4	1200' NE	86	44	128
6	20' N	6800	300	168
7	200' N	530	126	68
8	600' N	130	48	151
9	100' W	295	650	290
10	500' W	317	260	370
Control	1.8 miles NE	48	34	48

TABLE 3

Actual and Predicted
Lead Content of Ailanthus Foliage (Not Washed)
as of September 19, 1973

Station No.	Distance and Direction	Lead Content (ppm - dry weight)		
		Actual	Predicted	Variance
1	150' S	339	465	less
2	100' E	308	375	less
3	400' ENE	249	177	more
5	500' NNE	174	294	less
4	1200' NE	128	132	same
6	20' N	168	*	-
7	200' N	68	378	less
8	600' N	151	144	same
9	100' W	290	1950	less
10	500' W	370	780	less

* prediction not valid due to change in sample location from July 4 to September 19, 1973

6.2.4.7 Phytotoxicology Assessment Survey for Depth of Lead Contamination in Soil - November 21 - 22, 1973

Description of Investigation

The purpose of this survey was twofold:

1. to determine the depth to which soil is contaminated in the vicinity of the Toronto Refiners and Smelters plant in the event that replacement is necessary, and

2. to study the possibility of any lead contamination originating from lower geological materials.

At each station shown on the attached map (station locations correspond to those of the March 13, 1973 soil survey), soil samples were taken to a depth of 16 inches and separated for lead analysis into four-inch increments as follows: 0-4, 4-8, 8-12, and 12-16 inches.

Observation and Results

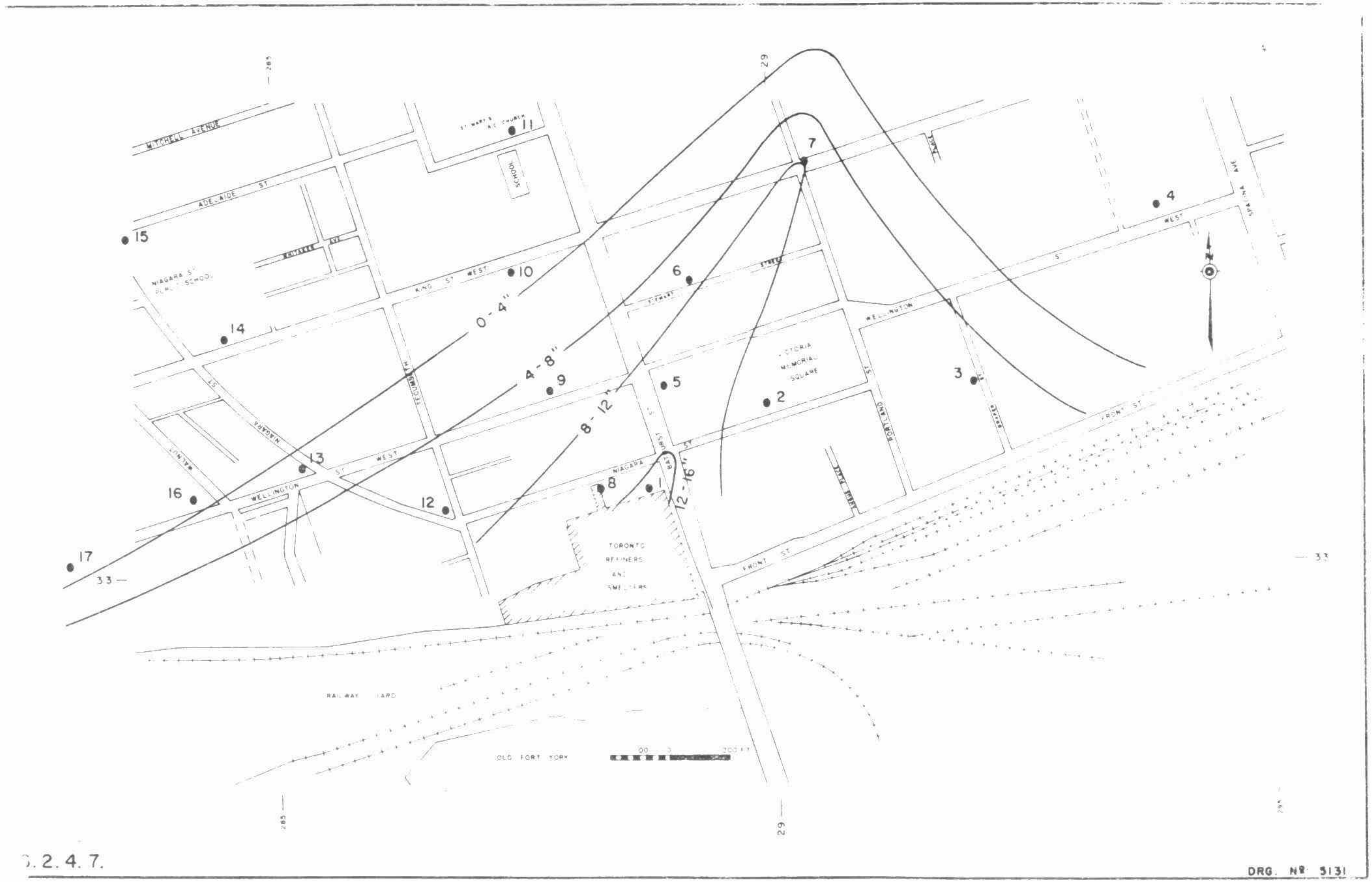
The lead content of all soil samples is shown in Table 1. Using the value of 500 ppm as an indication of excessive lead levels in soil, contamination isopleths for each of the four soil depths have been drawn on the attached map. This map could be used as a basis for determining excavation depth in the event that soil replacement becomes necessary.

It is apparent also from this map that lead is not originating from lower geological materials. The severity of contamination at low soil depths was found to decrease with increasing distance from the plant.

TABLE I

LEAD CONTENT OF SOILS COLLECTED IN THE VICINITY OF TORONTO REFINERS AND SMELTERS, NOVEMBER 21-22, 1973

Station No.	Distance from Source	Lead Content (ppm - dry weight)			
		0-4"	4-8"	8-12"	12-16"
1	100' ENE	208	1060	1280	1130
2	750' E	535	280	120	330
3	1500' E	608	528	53	88
4	2350' E	295	173	80	40
5	600' NE	1600	740	388	233
6	1000' NE	920	1180	950	135
7	1500' NE	868	738	570	228
8	50' N	5380	7180	775	228
9	300' N	1080	520	210	80
10	850' N	363	450	165	88
11	1200' N	265	155	93	75
12	350' NW	945	503	345	135
13	725' NW	570	508	93	28
14	1250' NW	155	120	25	30
15	1575' NW	45	23	25	80
16	1100' W	433	258	153	15
17	2250' W	625	11800	140	30



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DRG. Nº 5131

FIG - DEPTH OF SOIL CONTAMINATION NEAR TORONTO REFINERS AND SMELTERS
NOVEMBER 21 - 22, 1973

[redacted]

6.2.5 Toronto Refiners and Smelters Limited - Analysis

a) Abatement Activities

Toronto Refiners and Smelters has, under supervision of the Ontario Ministry of the Environment, taken action to reduce emissions of lead into the environment (see Section 6.2.2).

Since the fall of 1973 there have been no major improvements made and the Ministry and the City of Toronto Department of Public Health have been working to get the Company to erect an enclosed building to contain the stockpiles and the working scrap pile at the foot of Tecumseh Street which is suspected of being a mojor source of dust emissions. The Company agreed in principle to these requests but was unwilling to agree to all the conditions imposed by the City of Toronto in their conditional approval of a building permit. The matter is now stalled and both the City and the Ministry are seeking the most expedient way to force a resolution of the problem.

b) Suspended Lead Levels

Levels of suspended lead measured by Ministry of the Environment air sampling stations near the Toronto Refiners and Smelters plant are well above those normally found in downtown urban areas away from expressways and have exceeded both the existing and proposed air quality criteria of 15 $ug/m^3/24$ hours and 5 $ug/m^3/24$ hours and 2 $ug/m^3/30$ days respectively.

Correlations of the incidence of high lead levels with wind direction at both stations implicate Toronto Refiners as the major source of the high levels. Graphs show that there has been no obvious improvement in air quality since early 1973.

Particle size distributions measured by cascade impactors again show that there is a marked shift into the larger size range at both stations with winds from the plant. The particles are in the smaller size range at 150 feet north east of the plant and undoubtedly the distribution is influenced by some automotive generated lead from Bathurst Street. The particle size range 50 feet north west of the plant is much larger with an even greater tendency towards larger particles with winds from the plant. It is apparent that there may be a fallout of larger particles from 50 to 150 feet of the plant and this is supported by the rapid fall-off in dust fall levels with distance.

c) Dustfall

Levels of lead in dustfall in the vicinity of Toronto Refiners are extremely high with the highest levels ever reported being found some 10 feet from the property line on Tecumseh Street.

The computation of total dust fall-out in the area gives a value of 7½ to 16 lb/day which is greater than previous estimates made in December 1973. It is apparent that a very large reduction in fugitive dust emissions will be required to meet the desirable objective for lead in dustfall of 0.3 tons/mile^2/30 days.

It has been calcualted using the formula from section 2 that present rates of dustfall could cause unacceptable contamination of fresh surface soil in as little as 2½ years at 50 feet from the property line.

d) Vegetation Contamination

The lead contamination of foliar vegetation in the vicinity of Toronto Refiners and Smelters has been found to be excessive for distances of up to 600 feet north, 1200 feet east and 600 feet west of the plant. There was a marked decrease in levels found immediately to the north of the plant since the battery top crusher was relocated and controlled. The difference between not washed and washed lead levels in vegetation was indicative of a significant degree of surface contamination in line with the high levels of lead in dustfall and settleable particles also found.

Soil Contamination

During surveys made in 1972 and 1973, soil lead levels were found to be elevated in an area 1500 feet to the east and west of Toronto Refiners and 1200 feet to the north (0.2 square miles). There is a very high correlation of soil lead level with distance from the plant in the northwest, north-northeast, and east directions. Levels in excess of 10,000 ug/gram (1%)were found close to the plant.

Calculations show that contamination of replaced soil would be rapid close to the plant and 1974 surveys will indicate if there is a change as the calculations predict.

Dust Contamination

Samples of dust collected from streets and other horizontal surfaces showed above normal levels ranging from 0.2 - 7.7% weight. The higher of these values is above those reported in the literature for street dust in American cities.

Summary

Abatement actions taken by Toronto Refiners and Smelters to date do not appear to have been effective in reducing lead contamination of air, dustfall, soil and vegetation to acceptable levels.

The correlation of high suspended lead levels with winds from the plant and the fall-off in dustfall, soil and vegetation contamination with distance from the plant implicate ongoing plant operations as the major source of lead. Particle size distributions confirm this with large particles near to the plant and smaller particles at 150 feet away and indicate fugitive emissions may be the main problem.

6.3 ELTRA OF CANADA LIMITED, PRESTOLITE BATTERY DIVISION

6.3.1 Review of Plant Operations

This plant is located in an industrial area and on the southwest corner of Dufferin Street and Geary Avenue in the City of Toronto. An appended site plan, Figure 1, indicates the proximity of residences, within about 500 feet of the plant. There are industrial plants to the north, east and west and a Canadian Pacific Railway right-of-way immediately south of the plant.

Normal operations are on a five day per week basis employing approximately 130 persons, mostly on the day shift. The oxide mill is operated on a 24 hour basis. Some production operations are continued on a second or third shift as required.

The lead acid-battery making operations at this plant are essentially typical for the industry and may be briefly summarized as follows: (Flow Sheet 1)

Lead Oxide Production

Lead in pig form is melted in gas-fired melt pots and cast into small slugs for convenient feeding at controlled rates into rotating-drum ball mills. In these mills, the lead is reduced by impact, grinding and attrition to a fine, powdery form. Lead oxide is formed due to the heat of friction generated in the process and the continuous introduction of air into the mills. The lead oxide is withdrawn from the mills by air suction fans and collected in fabric filter units (baghouses). The filtered exhaust air is released to atmosphere.

The lead oxide (PbO) produced in this manner is transferred into steel drums for storage and subsequent use in the preparation lead oxide paste.

Paste Mixers

The lead oxide from the mills is dumped in measured quantities into fixed-drum rotating paddle mixers, sulphuric acid solutions added and a dough-like paste produced. Lead oxide dust is generated in the dumping and mixing phase and is exhausted from the area into the plant dust collection system.

Grid Casting

The lead grillages or "plate" grids which form the fundamental element in lead acid batteries are made automatically from molten lead in a line of grid-casting machines fed from a series of gas-fired melt pots. Lead bearing fumes from the melt pots and casting machines are exhausted from the area, through a cyclone to atmosphere. This is not a dusty operation and lead emissions are limited by the relatively low temperature of the melt pots.

Grid Pasting

In the grid-pasting machines, the oxide past is pressed by means of automated rollers into the cavities of the grids. The pasted grids are conveyed through gas-fired tunnel driers, brushed free of excessive paste and hand-stacked onto pallets. Lead oxide dust is generated in considerable quantities at the discharge

end of the tunnel driers due to the agitation and brushing of the plates. This dust is drawn from the operation into the dust collection system. Combustion fumes from the burners in the driers exhaust directly to atmosphere.

Plate Forming and Preparation

The pasted plates are air-cured for a period of time on the pallets, then transferred by hand into banks of acid filled tanks in a "forming room". Here they are inter-connected and a direct current voltage is applied for a period of time to convert them to a "charged" condition. On removal from the forming tanks they are dried in ovens. Acid fumes from the forming room are exhausted through a fume scrubber.

After drying, the plates, which are twice the required size, are cut in two with the aid of band saws located within mechanically ventilated enclosures. At this station they are also brushed free of excess paste. This operation produces considerable dust and the exhaust is connected to the dust collection system.

Battery Assembly

At various stations along assembly lines, the prepared plates are assembled into cells, the required number of cells are joined together into cell groups or units. These units are placed into the battery casing and the lid or top is applied and sealed in place.

At a number of these assembly stations, lead soldering is used to make the necessary electrical interconnections.

Some lead fumes are released as a result. These fumes and in addition, the lead-bearing dust generated in the handling of the plates during assembly, are exhausted through the plant dust collection system.

Miscellaneous Operations

In addition to the above operations the following potential secondary airborne lead sources should be mentioned:

The Small Parts Casting Operation

This is similar in principle to the grid casting, but of much smaller scale.

The Scrap Lead Melting Operation

Lead bearing scrap from the other plant operations is melted down in a separate gas-fired melt pot. Some lead fume and dust are generated at this station on occasion as it is used only on a periodic basis.

Waste Disposal

The dumping of lead dross accumulations and of baghouse collected dust into bulk containers at the south side of the plant for removal from the property, can be a fugitive dust source from time to time.

Plant Maintenance and Housekeeping

The emission of airborne lead-bearing dust from vehicular activity on the property is a potential problem depending upon housekeeping, both within the plant building and in the yard operations.

In summary, the operations which require consideration in any comprehensive lead emission control program for this plant are listed below with the relative priority and present status indicated.

SOURCE	RELATIVE PRIORITY *	STATUS JULY 1, 1974
Oxide milling	(1) (Major)	Controlled by baghouses
Paste mixing	(1)	
Grid pasting	(1)	
Plate preparation (saw parting)	(1)	
Battery assembly	(1)	
Plate forming	(2) (Secondary but important)	Controlled by wet scrubber
Plant housekeeping	(2)	On program
Yard housekeeping	(2)	
Grid casting	(3) (Minor)	Cyclone only, partial control
Small parts casting	(3)	Control imminent (by baghouse)
Scrap remelting	(3)	Control imminent (by baghouse)
Waste disposal	(3)	Further control measures required

* Potential for causing servere off-property effects if uncontrolled.

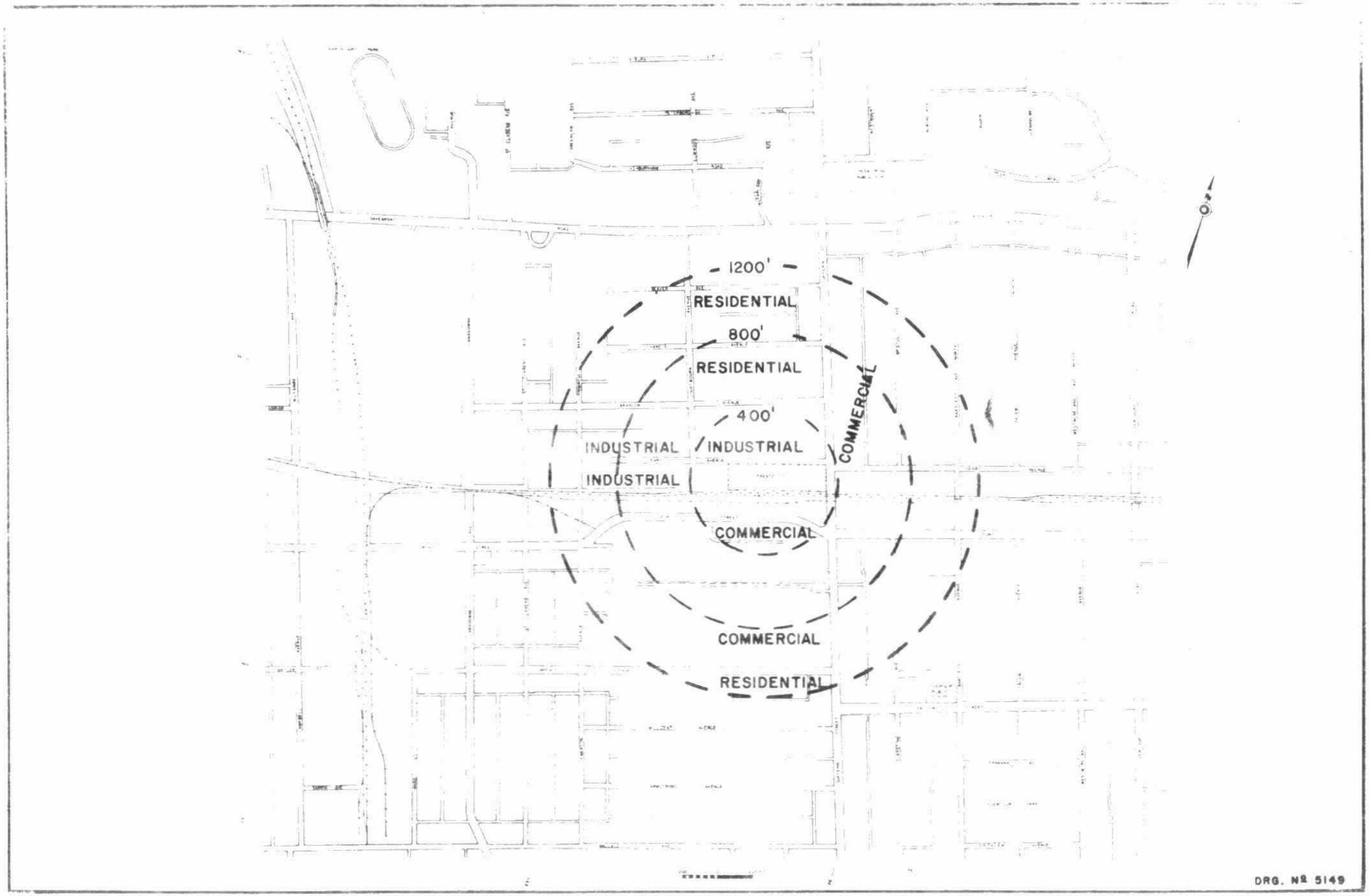
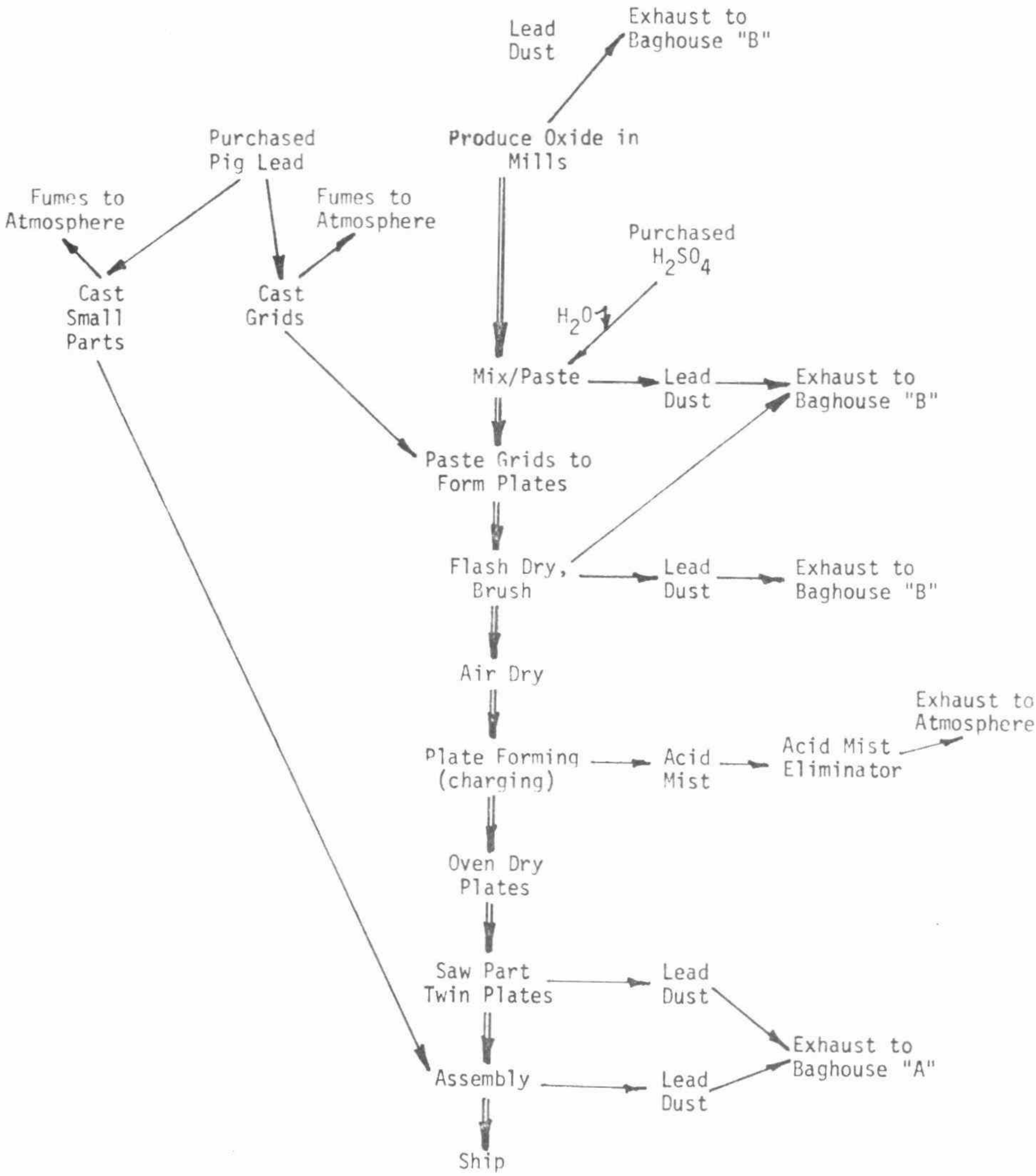


FIG. 6.3.1-1 LAND USE IN THE VICINITY OF PRESTOLITE, TORONTO.

Oxide Mill and
Battery Production.



Baghouse "A" - 35,000 cfm

Baghouse "B" - 35,000 cfm

1.3.2 Review of Abatement Activities - Prestolite

To date, the Company has taken the following abatement action:

a) An acid mist eliminator (wet scrubber type) has been installed on the exhaust to the forming room.

b) A high efficiency fabric filter (baghouse) has been installed to control lead dust emissions from the saw parting and from the assembly operations. This replaced existing, low-efficiency control equipment.

c) A high efficiency fabric filter (baghouse) has been installed to control lead dust emissions from the oxide mills, the past mixing and the grid pasting operations.

d) Bag failure detection devices have been installed on the above mentioned baghouses and an intensive program of regular bag inspection and replacement has been established.

e) The employee parking lot has been paved.

f) The scrap lead recovery operation has been discontinued temporarily, until a baghouse can be installed to control emissions from this source.

g) A program of improved housekeeping has been established to reduce yard traffic generated dust emissions.

h) The lead waste disposal area has been improved to allow better control of fugitive dust emissions.

i) Truck traffic areas in the plant yard have been repaved where necessary to facilitate housekeeping.

As of July 1, 1974, the Company has completed the installation of Ministry approved control equipment on all its major lead emission sources. Plant emissions are now being evaluated for full compliance with The Environmental Protection Act, 1971 and Regulations. Estimated particulate and lead emissions are given in Table 1, appended hereto. Stack emission tests are scheduled to complete this evaluation.

TABLE 6.3-1

ESTIMATED PARTICULATE & LEAD EMISSIONS

SOURCE (see attached sketch for locations)	HT. OF STACK (FT)	DIA. OF STACK (FT)	TOTAL PARTICULATE EMISSION RATE (Q) (LB/HR)	LEAD EMISSION RATE (Q) LB/HR	EGV (CFM)	EGT (°F)
Grid-Casting (1)	37	1.0	.45	.02	4515	140
			(bases on stack emission tests)			
Assembly (2)	50	3.5	2.93	0.62	36764	78
			(based on stack emission tests)			
Pasting (3)	55	3.5	3.0	3.0	35000	90
			(based on emission factor for baghouse stack emission tests scheduled July, 1974)			

FUGITIVE SOURCES	
(A) Dust emissions from vehicular yard traffic	Low level sources of local importance
(B) Dross disposal area (bulk lift container)	Emission rates indeterminate
(C) Plant ventilation to atomosphere (minor)	Effects to be estimated by area air quality monitoring soil smapling and vegetation surveys.

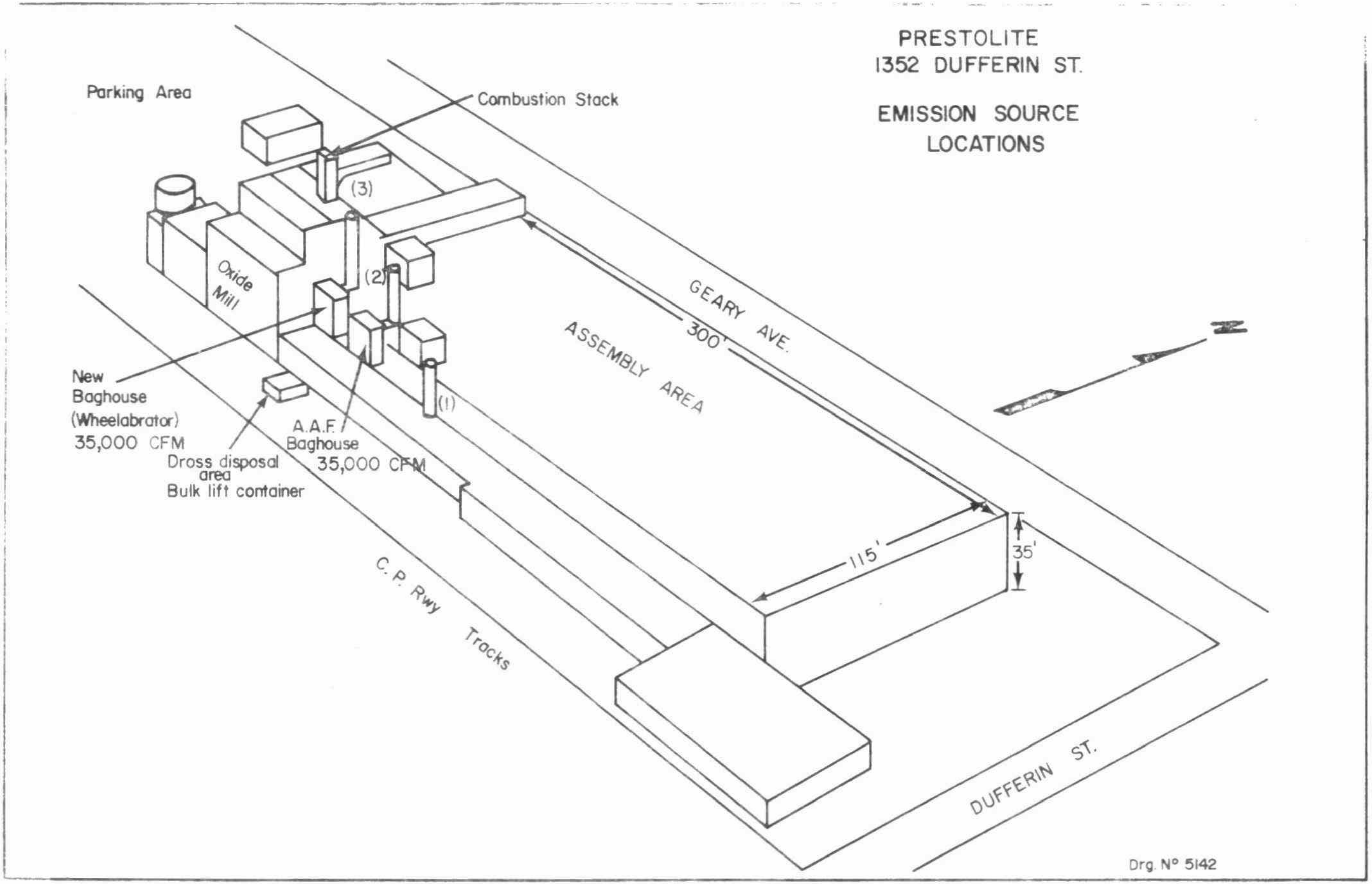


Figure 6.3.1-2 Prestolite - Emisson Source Locations

6.3.3 Summary of Airborne Lead Levels in Vicinity of Prestolite Co.

The locations of the sampling stations in vicinity of the Prestolite plant are shown in Figure 6.3.3-1. The lead content of suspended particulate measurements are summarized in Table 6.3.3-I and all lead in dustfall measurements obtained to date are given in Table 6.3.3-II(a) and (b).

For data obtained up to February 1974, significant correlations were obtained for lead concentrations in suspended particulate matter obtained at Stations No. 31063 and No. 31066 with hours of wind directions blowing from off plant property toward the sampling stations as indicated in Figures 6.3.3-2 and 6.3.3-3. During this period, the levels exceeded the 30-day geometric mean of 2 ug/m^3 with daily levels of lead frequently exceeding 5 ug/m^3 at Station No. 31063 (200 feet from Prestolite). and twice exceeding 15 ug/m^3. At Station No. 31065 (800 feet from Prestolite) the exceeding of 5 ug/m^3 was infrequent with the maximum concentrations exceeding 13 ug/m^3. The 30-day geometric mean concentration over the period measured met Ontario's criterion at this location. Data for Station No. 31079, which was established in late April 1974, have met Ontario's criteria for the period measured.

On March 22, 1974 the Prestolite plant was shut down during a strike and resumed operations on May 9, 1974. The lead levels met Ontario's criteria for both daily levels and monthly geometric means for all samples for March and April 1974. The strike has made it impossible to determine if the improvement in air quality was due to abatement actions of the source. Figures 6.3.3-4 and 6.3.3-5, which show the 28-day and 7-day moving averages of lead at Station 31063 along with the frequency of wind from the direction of the plant to the sampling station, indicate some im-

provement beginning before the strike began. However, an analysis of data obtained since the company began operations after the strike will determine whether the improved air quality will be sustained.

At the nearest sampling station (31062), levels of lead in dustfall continued to exceed Ontario's guideline of 0.30 ton per square mile per 30 days for the month of April, 1974, during which the company was on strike. This is possibly a reflection of the contamination of the soil in the area as well as wind blown dust from plant property.

TABLE 6.3.3-I

PRESTOLITE
LEAD LEVELS IN SUSPENDED PARTICULATE MATTER

tion o.	Location Name	Location Description	Period Sampled	No. of Days Sampled	Geom. Mean $\mu g/m^3$	Maximum Conc. $\mu g/m^3$	No. of Days Conc. >5 $\mu g/m^3$	% of Days Conc. >5 $\mu g/m^3$	No. of Days Conc. >15 $\mu g/m^3$	% of Days Conc. >15 $\mu g/m^3$
063	226 Geary St.	200 ft. ENE of Prest.	10/11/73 to 13/5/74	169	2.21	31	25	15	2	1
066	1245 Dupont St.	550 ft. SW of Prest.	9/12/73 to 30/4/74	117	1.26	13	4	3	0	0
079	1285 Dufferin St.	700 ft. SE of Prest.	1/5/74 to 31/5/74	24	1.43	4	0	0	0	0

TABLE 6.3.3-II(a)

LEAD IN DUSTFALL RESULTS - PRESTOLITE

TONS PER SQUARE MILE PER MONTH

1 9 7 3

STATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
31062										3.36	1.63	0.67	
31063												0.20	

TABLE 6.3.3-II(b)

LEAD IN DUSTFALL RESULTS - PRESTOLITE

TONS PER SQUARE MILE PER MONTH

1974

STATION NO.	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
31062	1.77*	1.32	1.74	.61	.64							
31063	.12*	.24	.24	.06	.20							

* INSOLUBLE lead only

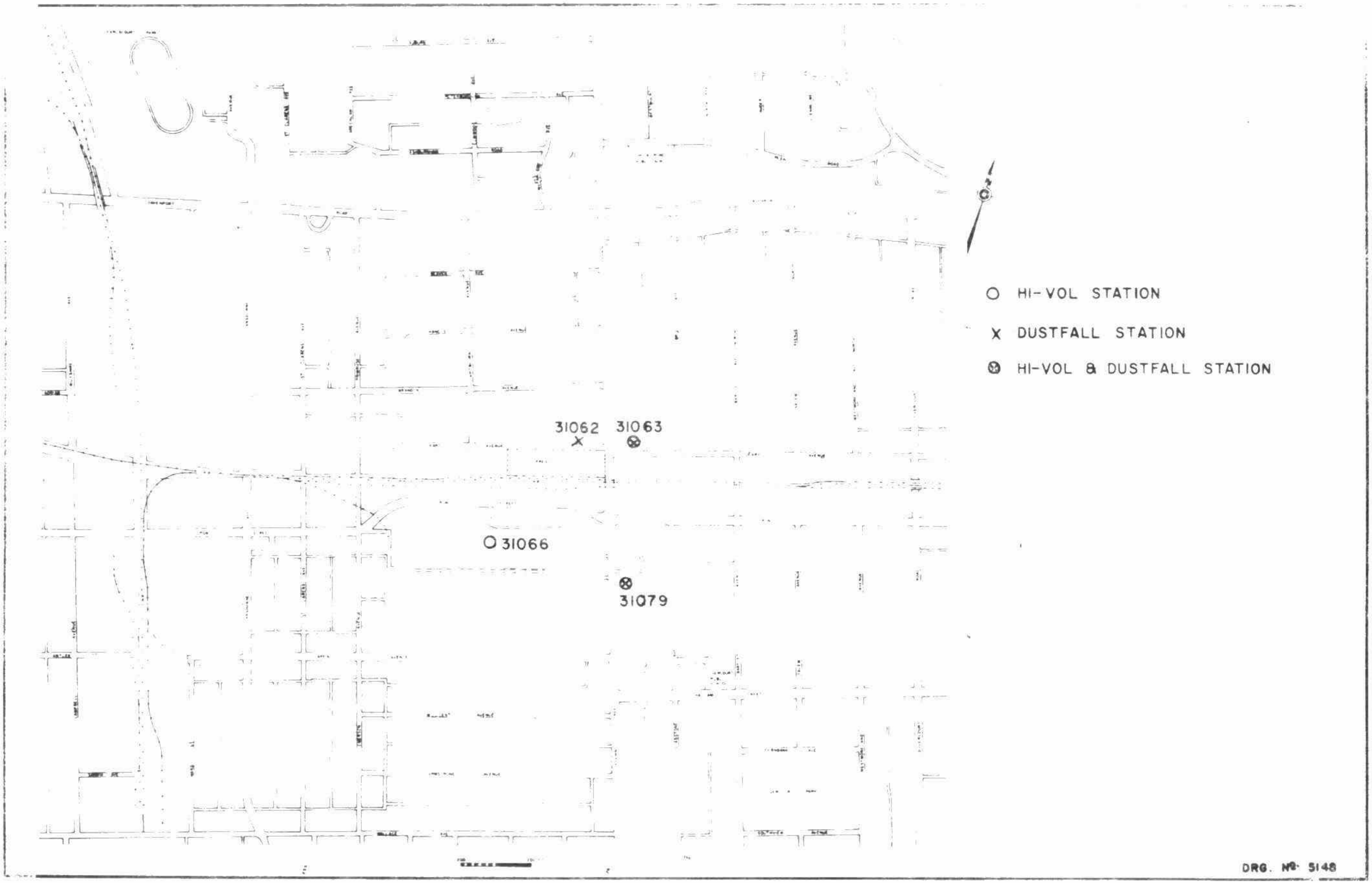
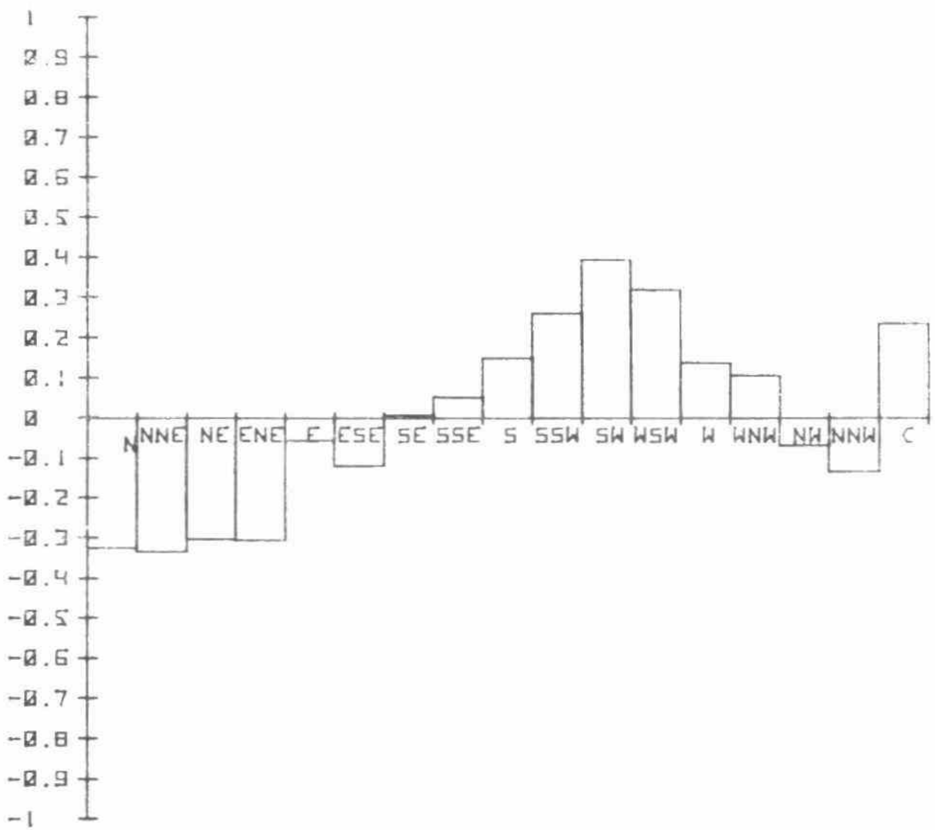


FIG. 6.3.3-1 LOCATION OF AIR MONITORING STATIONS NEAR PRESTOLITE

FIG. 6. 3. 3-2 STATION NO 31063 FROM 10/11/73 TO 31/3/74 125 READINGS

CORRELATION COEFFICIENTS
OF PARTICULATE WITH WIND
DIRECTION



CORRELATION COEFFICIENTS
OF LEAD WITH WIND
DIRECTION

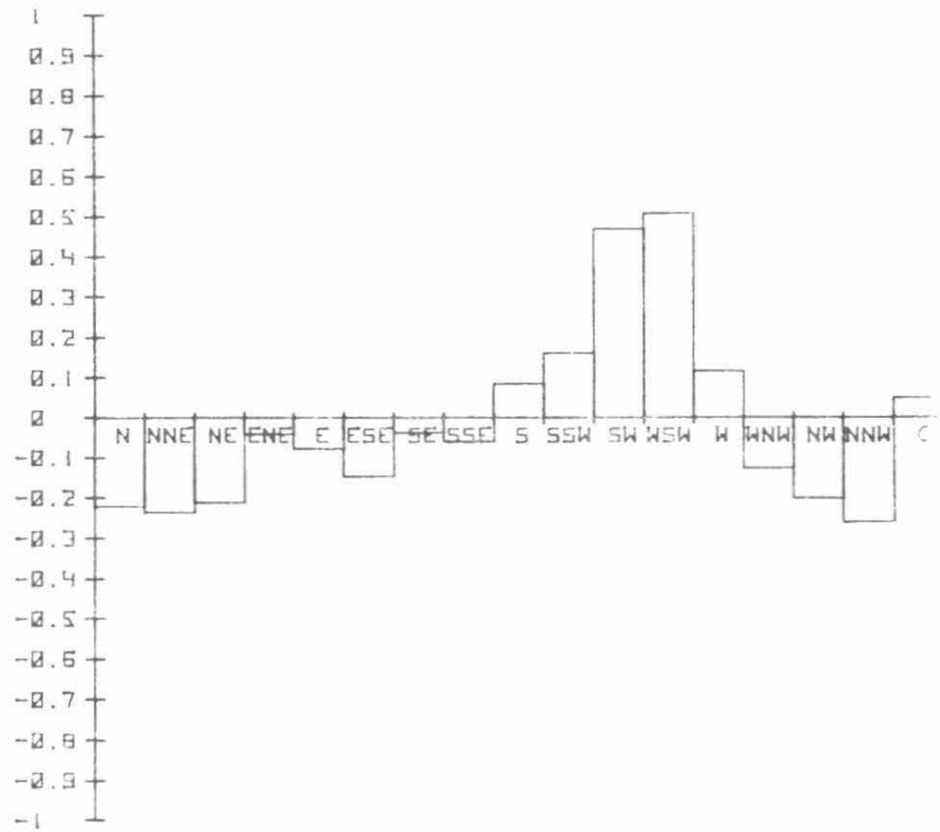
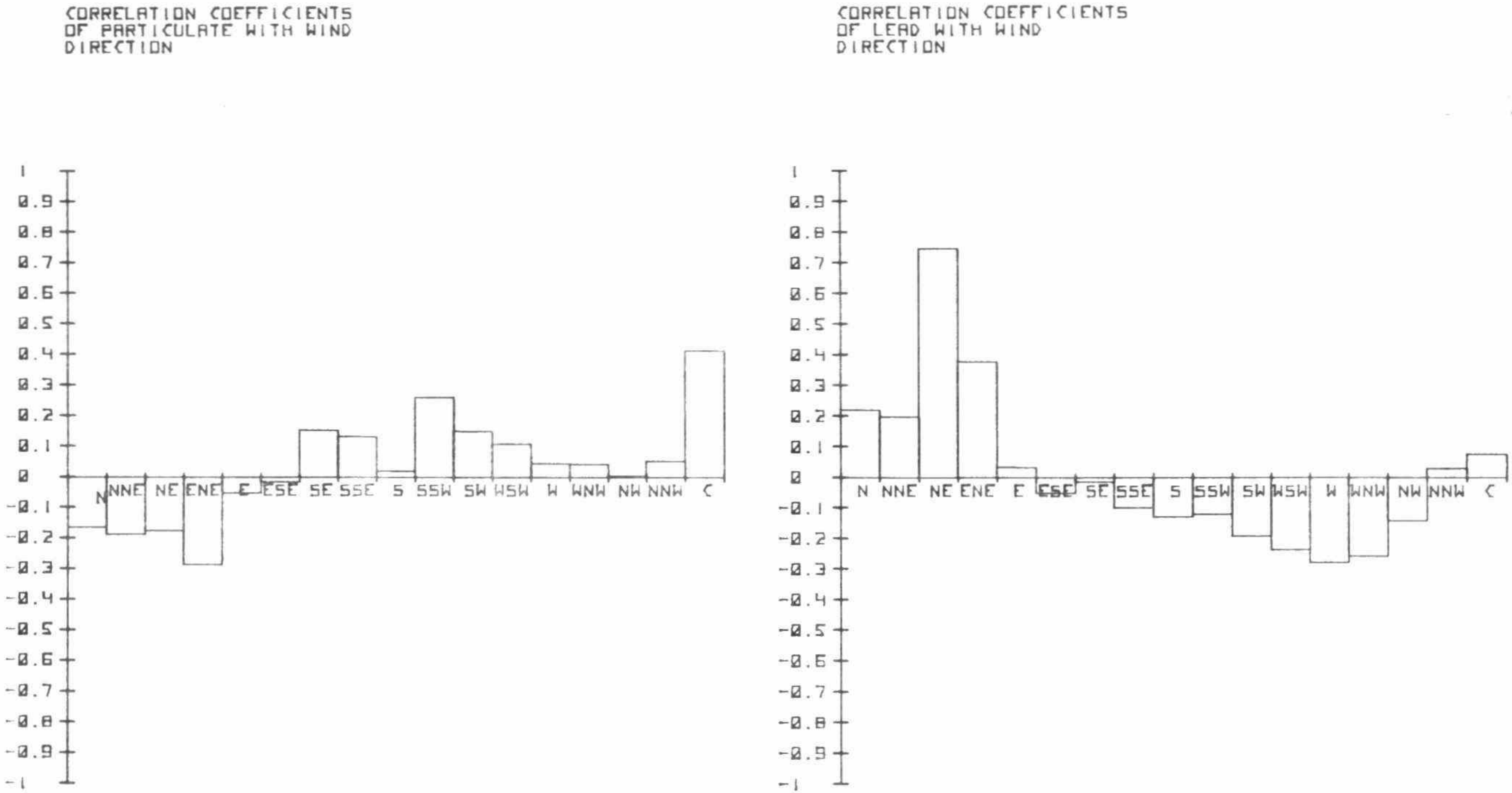


FIG. 6.3.3-3 STATION NO 31066 FROM 9/12/73 TO 31/3/74 93 READINGS



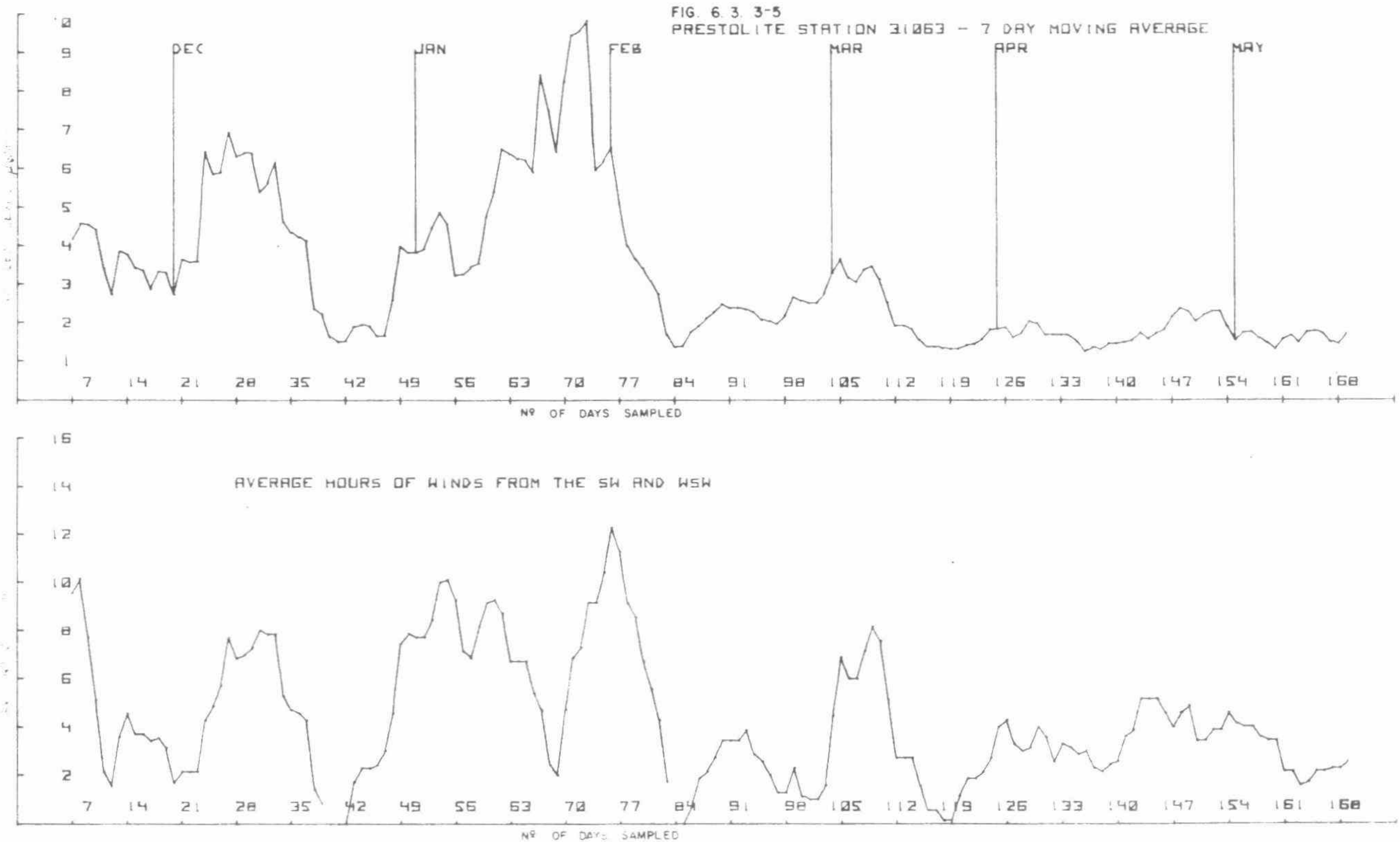


FIG. 6.3.3-5
PRESTOLITE STATION 31063 - 7 DAY MOVING AVERAGE
DEC
JAN
FEB
MAR
APR
MAY
Nº OF DAYS SAMPLED
AVERAGE HOURS OF WINDS FROM THE SW AND WSW
Nº OF DAYS SAMPLED

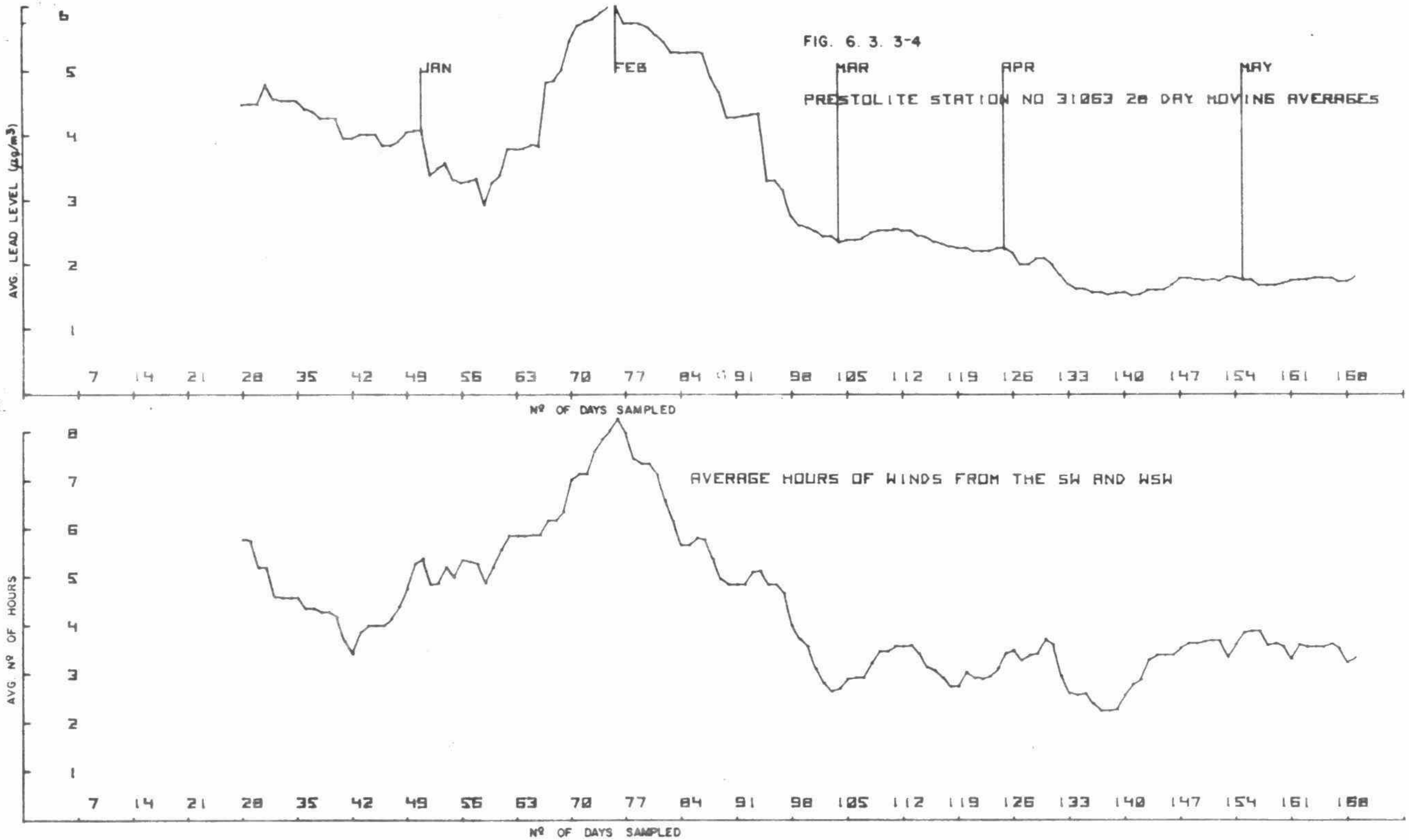


FIG. 6. 3. 3-4
PRESTOLITE STATION NO 31063 28 DAY MOVING AVERAGES
JAN
FEB
MAR
APR
MAY
AVG. LEAD LEVEL (μg/m³)
Nº OF DAYS SAMPLED
AVERAGE HOURS OF WINDS FROM THE SW AND WSW
AVG Nº OF HOURS
Nº OF DAYS SAMPLED

6.3.4 Summary of Lead Levels in Soil and Vegetation in the Vicinity of Prestolite Battery Ltd., 1352 Dufferin St., Toronto

The key conclusions of phytotoxicology assessment surveys conducted in the vicinity of Prestolite Battery Company in 1972 and 1973 are:

1) A survey conducted in September 1972 showed excessive levels of lead in vegetation at three locations immediately adjoining Prestolite Battery.

2) In July 1973, a survey was conducted to determine lead contents in vegetation at 10 locations in the vicinity of Prestolite Battery. Excessive levels of lead were detected in vegetation to a distance of 1000 feet west of the battery manufacturing area.

3) In November 1973, an expanded soil and vegetation survey was carried out. Elevated lead levels were found in all foliage samples collected up to 600 feet north, south and east, and up to 1000 feet west of the source. Lead values significantly higher than normal were found in surface and sub-surface soil collected up to 300 feet north and east, and up to 1000 feet west of the source.

Descriptions of these surveys follow, which include sampling locations, analyses results and their interpretation.

6.3.4.1 Phytotoxicology Assessment Survey for Lead in Vegetation - September 28, 1972

Description of Investigation

On September 28, 1972, a vegetation survey was conducted in the vicinity of Prestolite Battery Ltd., a potential source of heavy metal emissions. Foliage samples were collected from Manitoba Maple trees at distances of (1) 100 feet south; (2) 100 feet east; and (3) 120 feet northwest of the company (Figure 1).

A control sample was collected in the Claireville Conservation Area, 7 miles northwest of Metro Toronto. The washed and not washed foliage samples were analyzed for total S, Cd, Cl, Pb, V and Zn.

Results of Chemical Analysis

The results of the chemical analysis of Manitoba maple foliage are presented in Table 1. The lead content of foliage collected around the Prestolite Company was substantially higher than normal for urban vegetation, and much higher than in the rural control sample. The other metals were within normal limits for urban vegetation.

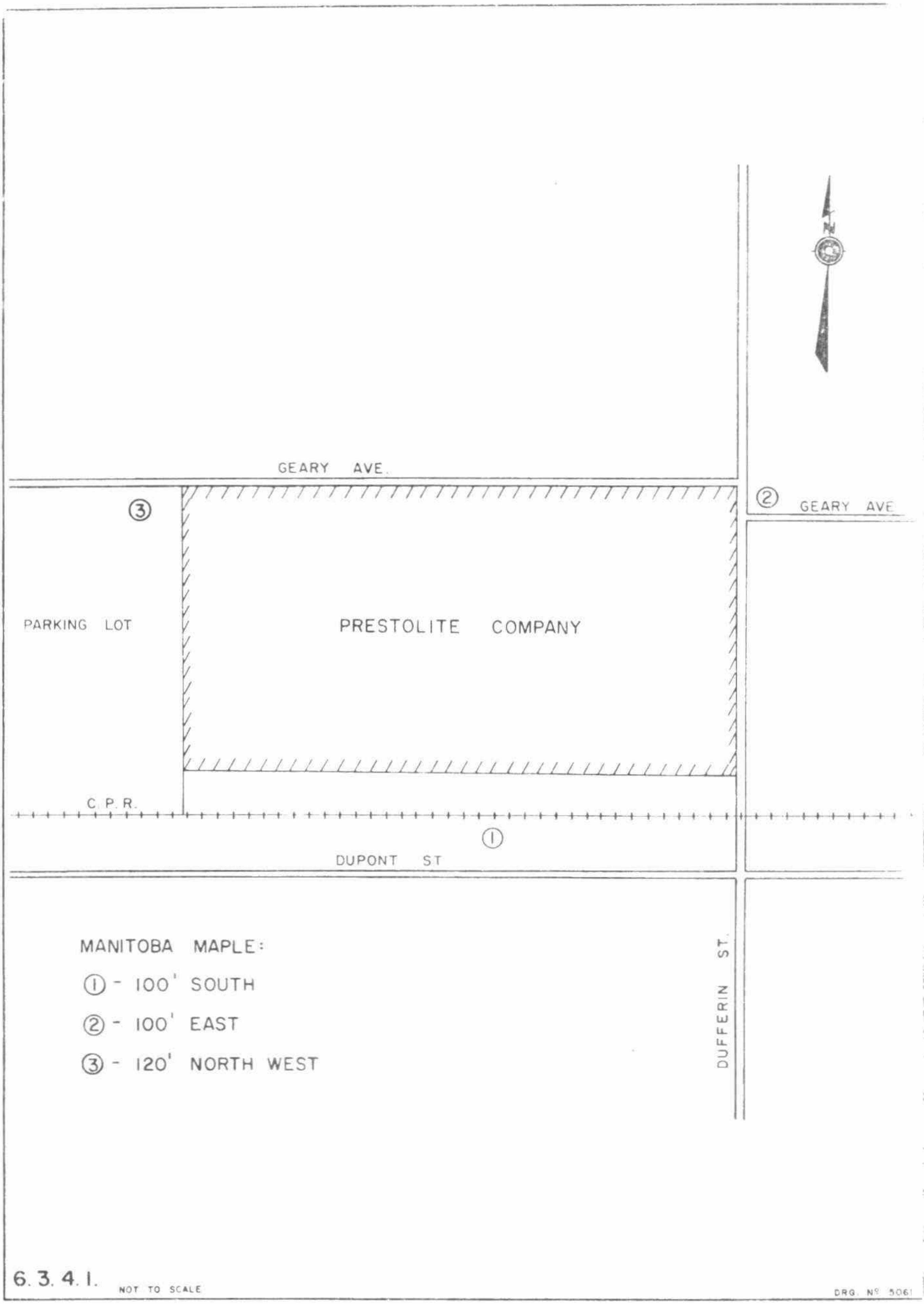


FIGURE 1 - LOCATION OF VEGETATION SAMPLES
COLLECTED AROUND PRESTOLITE COMPANY - SEPT. 26

TABLE I.
Heavy Metal Content of Maple Foliage, in PPM Dry Weight.
September 28, 1972

Location	Cd		Pb		V		Zn	
	NW	W	NW	W	NW	W	NW	W
Prestolite:								
100' S	1.9	1.7	650	360	5	4	72	58
100' E	1.8	1.4	410	200	6	5	73	53
120' NW	1.9	1.2	640	310	5	4	46	40
Highway vegetation, Metro average:	1.1	1.0	107	64	4	3	49	42
Control:	2.4	1.6	36	30	4	4	21	19

6.3.4.2 Phytotoxicology Assessment Survey for Lead in Vegetation - July 26, 1973

Description of Investigation

On July 26, 1973, vegetation was sampled at 10 locations in the vicinity of Prestolite Battery Limited. Samples of Norway and Manitoba Maple foliage were collected at various directions and distances from the source and analysed for lead. The results of these analyses are shown in Table 1.

The lead content of maple foliage collected up to a distance of 1000 feet from the battery manufacturing area was substantially higher than normal for urban vegetation. Lead levels in foliage collected close to the source were similar to levels found in 1972.

TABLE I - Lead Contents of Maple Foliage Collected in the Vicinity of Prestolite Co., Dufferin St., Toronto

JULY 26, 1973

Direction and Distance from Source	Pb Content, washed foliage parts per million dry weight
50 feet S	350
3500 " S	31
150 feet E	112
4000 " E	52
200 feet W	320
850 " W	190
1000 " W	101
225 feet N	250
1000 " N	79
3000 " N	48
Metro Toronto average	32 $\pm$ 15

6.3.4.3 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - November 7, 1973

Description of Investigation

On November 7, 1973, vegetation and soil samples were collected at 20 locations in the vicinity of Prestolite Batteries Ltd. Samples were collected at distances of 100, 300, 600, 1000 and 2000 feet, north, south, east and west of the battery plant. At most stations, samples were collected from tree and shrub foliage, grass, and soil at depths of 0-2 inches and 2-4 inches. At some locations, one or more of the vegetation species were not available for sampling; however, soil was collected from every sampling station except 600 feet south. Half of each vegetation sample was washed prior to chemical analysis and the remainder was analyzed unwashed. All lead analyses were conducted by atomic absorption spectroscopy.

Results of Chemical Analysis

1) Lead Content of Vegetation

The results of the chemical analysis for lead content of tree and shrub foliage are given in Table 1A. Elevated lead levels were found in all foliage samples collected up to 1000 feet in all directions from the battery manufacturing area. Levels significantly higher than normal were found in samples collected up to 600 feet north, south and east, and up to 1000 feet west of the source. The correlation between lead content of foliage and distance from source was highly significant for both washed and not washed samples collected north, south and east of the source, but was not significant for samples collected to the west of Prestolite. In every direction, lead content decreased with increasing distance from the source, but this reduction was not as rapid to the west of the plant.

The results of the chemical analysis of grass samples are given in Table 1B. The pattern of lead contamination in grass was similar to that of tree and shrub foliage, with high lead levels found in samples collected up to 600 feet north and east, and up to 1000 feet west of the source. Correlation between lead content in grass samples and increasing distance from the source was again statistically significant for samples collected north, south and east of the battery plant (Table 1). The vegetation samples contained reduced lead levels with increasing distance from the source, as shown in Figure 1.

Figures 2 and 3 depict the zones of excessive levels of lead found in not washed and washed vegetation surrounding the Prestolite plant.

2) Lead Content of Soil

Lead levels in soil samples collected in the vicinity of Prestolite are given in Table 2. Lead values significantly higher than normal were found in surface and sub-surface soil collected up to 300 feet north and east, and up to 1000 feet west and south of the source. The highest lead levels were found in soil in an unpaved parking lot west of the battery manufacturing area. Except for sub-surface soil collected to the east, the correlation between lead in surface and sub-surface soil and distance from Prestolite was statistically highly significant.

The area surrounding Prestolite Battery in which soil samples contained higher than normal amounts of lead for an urban area extended from Bartlett Street on the east, Chandos Street on the north, St. Clarens Avenue on the west, to Lappin Street on the south (Figure 4).

TABLE I

AVERAGE LEAD LEVELS IN WASHED AND NOT WASHED VEGETATION
COLLECTED AROUND PRESTOLITE BATTERIES,
IN PARTS PER MILLION, DRY WEIGHT

Distance from Source	Direction							
	N		S		E		W	
	NW	W	NW	W	NW	W	NW	W
A. Tree & Shrub Foliage								
100'	433	259	398	315	282	149	184	148
300'	228	170	-	-	-	-	-	473
600'	127	115	-	-	108	82	119	92
1000'	51	39	53	37	126	48	146	147
2000'	37	30	40	29	47	29	-	42
Correlation r= coefficient	-0.92*	-0.98**	-0.98**	-0.98**	-0.97**	-0.99**	-0.80	- 042
B. Forage (grass)								
100'	388	253	121	222	145	108	154	213
300'	136	101	338	135	81	44	103	40
600'	132	32	-	-	100	66	-	-
1000'	30	20	21	5	27	16	156	87
2000'	41	24	-	-	25	14	32	23
Correlation r= coefficient	-0.92*	-0.92*	-0.33	-0.99**	-0.91*	-.90*	-0.62	-0.7[illegible]

* significant at 5% level

** significant at 1% level

NW - Not Washed

W - Washed

TABLE 2

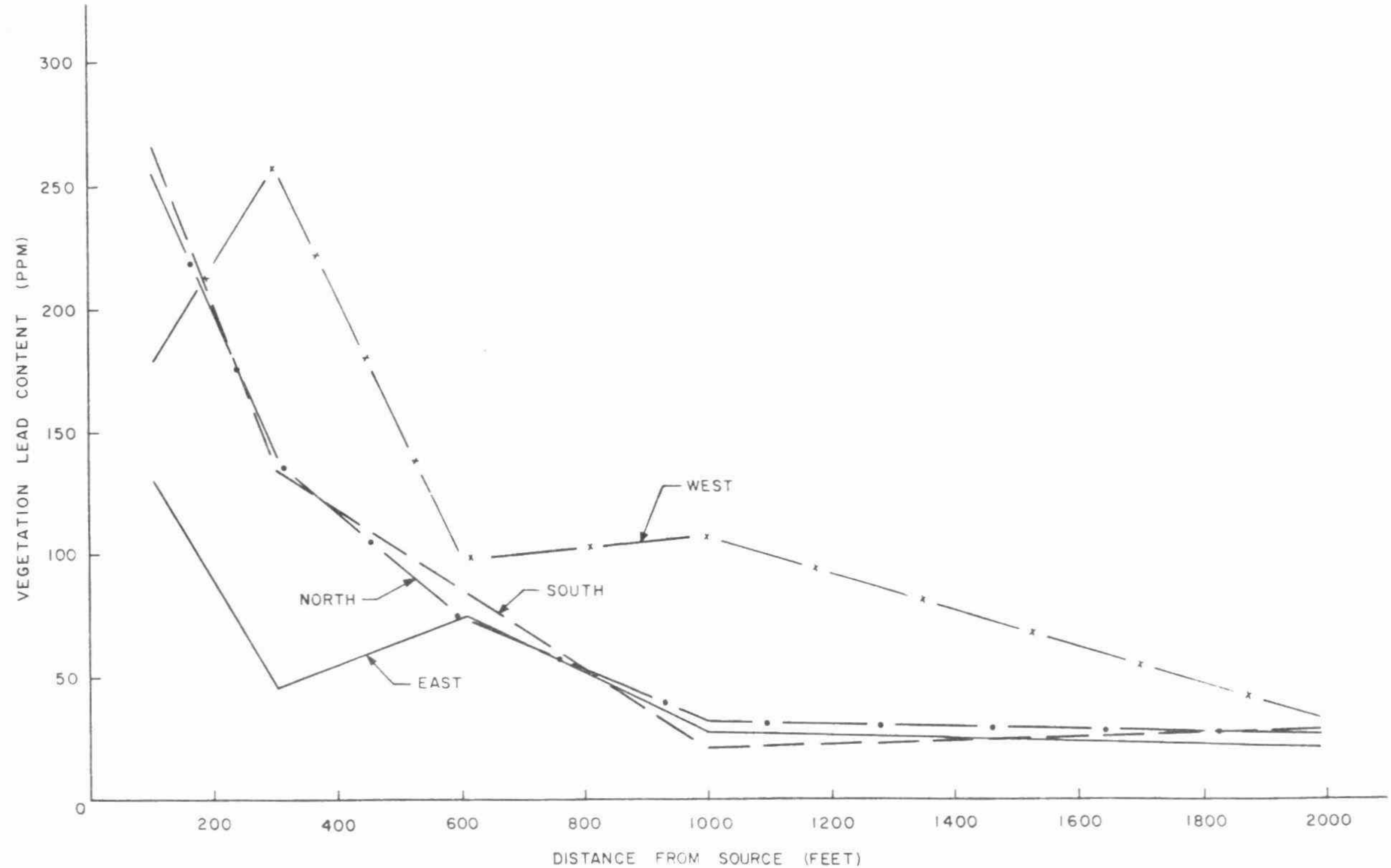
LEAD CONTENT OF SOIL COLLECTED AROUND PRESTOLITE BATTERIES, IN PARTS PER MILLION, DRY WEIGHT

Distance from Source	Direction: N		S		E		W	
	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"	0-2"	2-4"
100'	1030	565	1950	1630	1000	350	17,300[1]	16,500[1]
300'	883	265	1230	865	590	423	9,250[1]	4,850[1]
600'	335	153	-	-	395	198	560	458
1000'	320	183	643	603	313	223	673	863
2000'	95	98	118	73	338	170	318	355
r=	-0.95**	-0.93**	-0.997**	-0.98**	-0.93**	-0.78	-0.93**	0.90*

Metro Toronto Average 0-1" 291
4-6" 148

1 - In Parking Lot

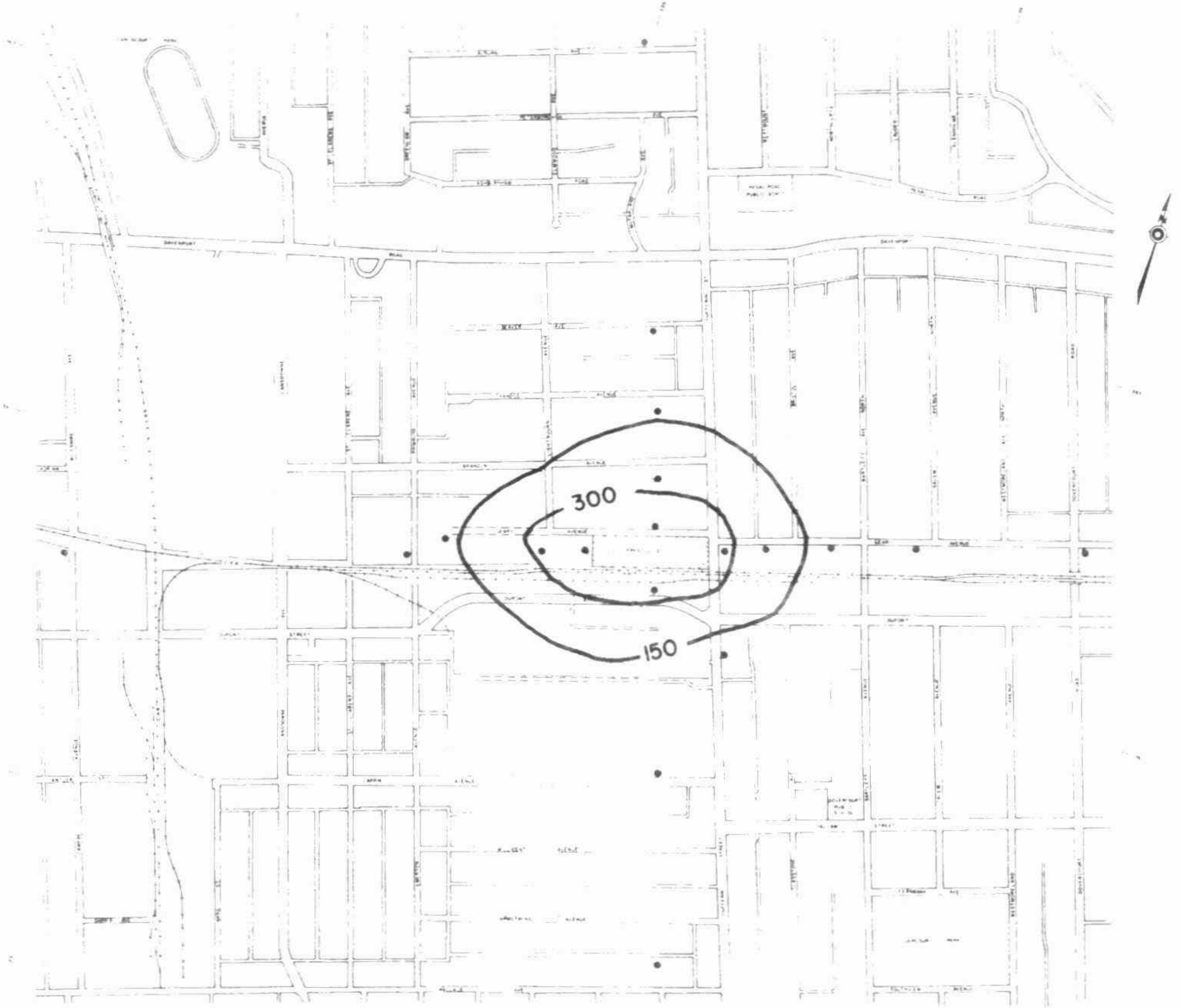
* significant at 5% level
** significant at 1% level



6. 3. 4. 3.

DRG NY 5062

FIGURE 1 - RELATIONSHIP BETWEEN LEAD CONTENT OF VEGETATION AND DISTANCE FROM PRESTOLITE BATTERIES NOV 7, [illegible]

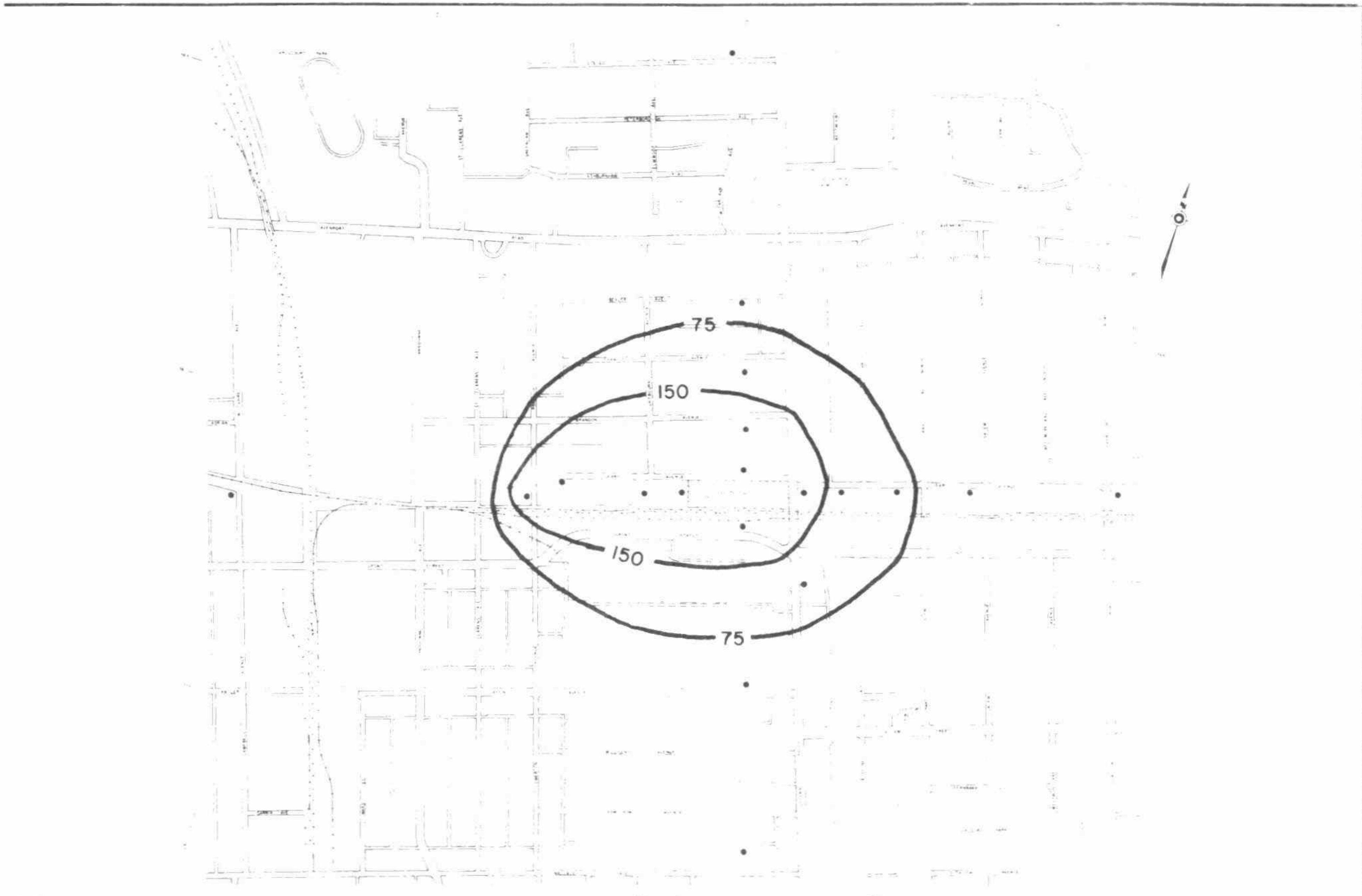


3. 4. 3.

DRG. Nº 5128

FIG. 2 - ZONES OF LEAD CONTAMINATION (IN ppm) IN UNWASHED TREE AND SHRUB FOLIAGE NEAR

... 7, ...



3.4.3.

DWG Nº 5129

FIG. 3.4.3 ZONES OF LEAD CONTAMINATION (IN ppm) IN WASHED TREE AND SHRUB FOLIAGE NEAR [illegible]
NOVEMBER 7, 1973.

6.3.4.3.

DRG. Nº 5130

FIG 4 - ZONES OF LEAD CONTAMINATION (IN ppm) IN SURFACE SOIL (0 2" DEPTH) NEAR PRESTOLITE

NOVEMBER 7,

6.3.5 Analysis Eltra of Canada Limited - Prestolite Battery Division (Prestolite)

a) Abatement Activities

In the past 6 months, Prestolite have, under Ministry supervision, completed the major abatement measures required to reduce emissions from the battery manufacturing and assembly operations at the Dufferin Street Plant. Compliance will be checked by stack testing of the newly controlled and existing emission points in August, 1974.

The installation of new control equipment on the grid and small parts casting processes is not yet completed and certain housekeeping and waste disposal problems still need attention to eliminate fugitive dust emissions.

b) Suspended Lead Levels

Suspended lead levels in the vicinity of the Prestolite plant from December, 1973 to mid March, 1974, were frequently in excess of the proposed air quality criterion of 5 ug/m3/24 hours and also on occasion, the present criterion of 15 ug/m3/24 hours. Wind correlations implicated Prestolite as the major cause of these high levels.

In Mid-March, a labor dispute stopped production at the plant for 6½ weeks. During this time, suspended lead levels were much lower than measured prior to March, 1973, and met Ontario's proposed criteria.

The results of air sampling conducted since production resumed are not yet available and analysis of the situation will also be complicated by the abatement measures completed by the Company in the past 3 months. It is not likely that definitive

statements regarding the success of abatement measures can be made before October, 1974.

c) Lead in Dustfall

The lead content of dustfall in the area of Prestolite was elevated during late 1973 to early 1974 to distances of at least 800 feet from the plant. However, levels in excess of the suggested guideline for the lead in dustfall were only measured at 200 feet from the plant and levels at 800 feet were slightly below the guideline.

During the strike, levels at the close in station (200 feet) dropped by a factor of 2-3, but still remained above the suggested guideline. This could be due to dust emissions from horizontal surfaces most probably from within the plant property.

d) Lead In Soil

The lead content of soil in the vicinity of Prestolite was found to be significantly higher than normal in both surface and subsurface soil at distances of 300 feet north and east and 1000 feet west of Prestolite. The highest lead concentrations in an employee parking lot were in excess of 2000 ppm dry weight with a maximum value of 17,000 ppm.

The lead content of surface soil decreased in a statistically significant manner in all directions from Prestolite implicating the plant as the source of lead contamination.

e) Lead in Vegetation

The lead content of not washed and washed vegetation in the vicinity of Prestolite in 1973 was elevated for distances up to 1000 feet from the plant. The correlation between distance from Prestolite and lead content was highly significant for both not washed and washed samples collected north, south and east of the plant.

Grass samples were also contaminated for distances up to 1000 feet from Prestolite and again, the lead content decreased in a statistically significant manner with distance from the plant.

Summary

In 1973, the operations of Prestolite were found to be the cause of elevations of lead in the air, soil and vegetation in the vicinity of the plant for distances up to 1000 feet. Abatement actions taken by the company have almost been completed at least with respect to the major emission sources and, in addition, some improvements in house-keeping have been made.

To date, it is difficult to assess the impact of these measures on lead levels in the Environment, particularly since a labor dispute closed the plant down in the period immediately after installation of some major air pollution control equipment with the result that lead levels in the air and dustfall dropped markedly almost to acceptable levels.

The Company still has to [illegible] action to control [illegible] sources of lead

emissions and will test the exhausts from control equipment in August to check on compliance with the Environmental Protection Act, 1971.

A few months more air quality data, supported by soil and vegetation surveys and emission compliance tests should enable a positive assessment of the degree of improvement in environmental lead levels to be made by October, 1974.

6.4 TONOLLI COMPANY OF CANADA LIMITED

6.4.1 Review of Plant Operations - Tonolli

The company manufactures aluminum, brass, bronze and lead ingots from scrap using various metallurgical furnaces. This report deals only with the processing of lead.

For lead recovery, mixed scrap is used as raw materials. Whole batteries are delivered and dumped on the yard ground to crack the casings. Further crushing is performed by a bulldozer running over the batteries and the mixed scrap is stored in a building. From storage, the mixed scrap is charged to a rotary battery crusher and dryer, and then to a series of screens to separate the paper, casings, lead plates and lugs. Water is used in the separation process and some of the lead oxide is carried in slurry to be separated by settling. The bulk lead scrap of grids and lugs are conveyed and stored inside a building. The cleaned crushed casings are belt-conveyed to bulk lift containers outside and ultimately disposed off site.

The recovered lead plates and oxide are weighted into containers and are charged to one of three rotary furnaces. The melt from the furnaces flows directly into one of three kettles or to one of two reverberatory furnaces for further refining. Further alloying is performed in one of three additional kettles.

The refined and alloyed lead is charged to one of four holding kettles, from which lead blocks are cast or alternately converted into ingots, using an automatic rotary casting machine.

Emissions

1) Rotary Battery Crusher - Certificate of Approval #73/4/381 July 19, 1973

Lead Emissions	-	0.24 lb/hr.
Sulphuric Acid Emissions	-	0.02 lb/hr.

Particulate (other than lead) not available

2) Lead Refining - Certificate of Approval #91/4/366 September 23, 1971
Baghouse for 2 reverberatory, 3 rotary and 6 kettle furnaces

Lead Emissions	-	1.26 lb/hr.
Particulate	-	0.54 lb/hr.
Sulphur Dioxide	-	15 lb/hr.

3) Initial Battery Breaking

Emission data not available

Total Emissions (excluding fugitive emissions)

Lead	-	1.50 lb/hr.
Particulate	-	0.54 lb/hr.
Sulphuric Acid	-	0.02 lb/hr.
Sulphur Dioxide	-	15 lb/hr.

6.4.2 Review of Abatement Activities - Tonolli

Following surveys and recommendations by the Ministry of the Environment, the Company took the following actions to reduce emissions:

1) Installed a baghouse and 60-foot-high stack to control the emissions from three rotary furnaces, six casting and refining kettles, and two reverberatory furnaces.

2) Installed a new battery crusher and separatory to control emissions from the lead separating process and reduce emissions from subsequent lead melting furnaces.

3) Improved housekeeping in handling lead dust from baghouse by the use of covered tote boxes.

4) Improved housekeeping through sweeping and dampening of the yard.

5) Modified speed control of rotary furnaces to minimize emissions during critical phase of operation.

6) Modified exhaust hoods and ducts at the rotary furnaces to improve control of emissions and upgraded quality of filter fabric used in baghouse to improve efficiency.

7) Installed an additional gas-fired burner to crusher dryer to reduce particulate.

8) Purchased a wet yard sweeper and increased sweeping frequency.

9) Made the following modifications to yard operations:

a) installed a 10-ft.-high concrete wall along open sections;
b) relocated lead scrap storage piles;
c) segregated traffic from storage areas;
d) constructed enclosure around baghouse.

10) Most recently, the following abatement measures were taken to further reduce lead emissions:

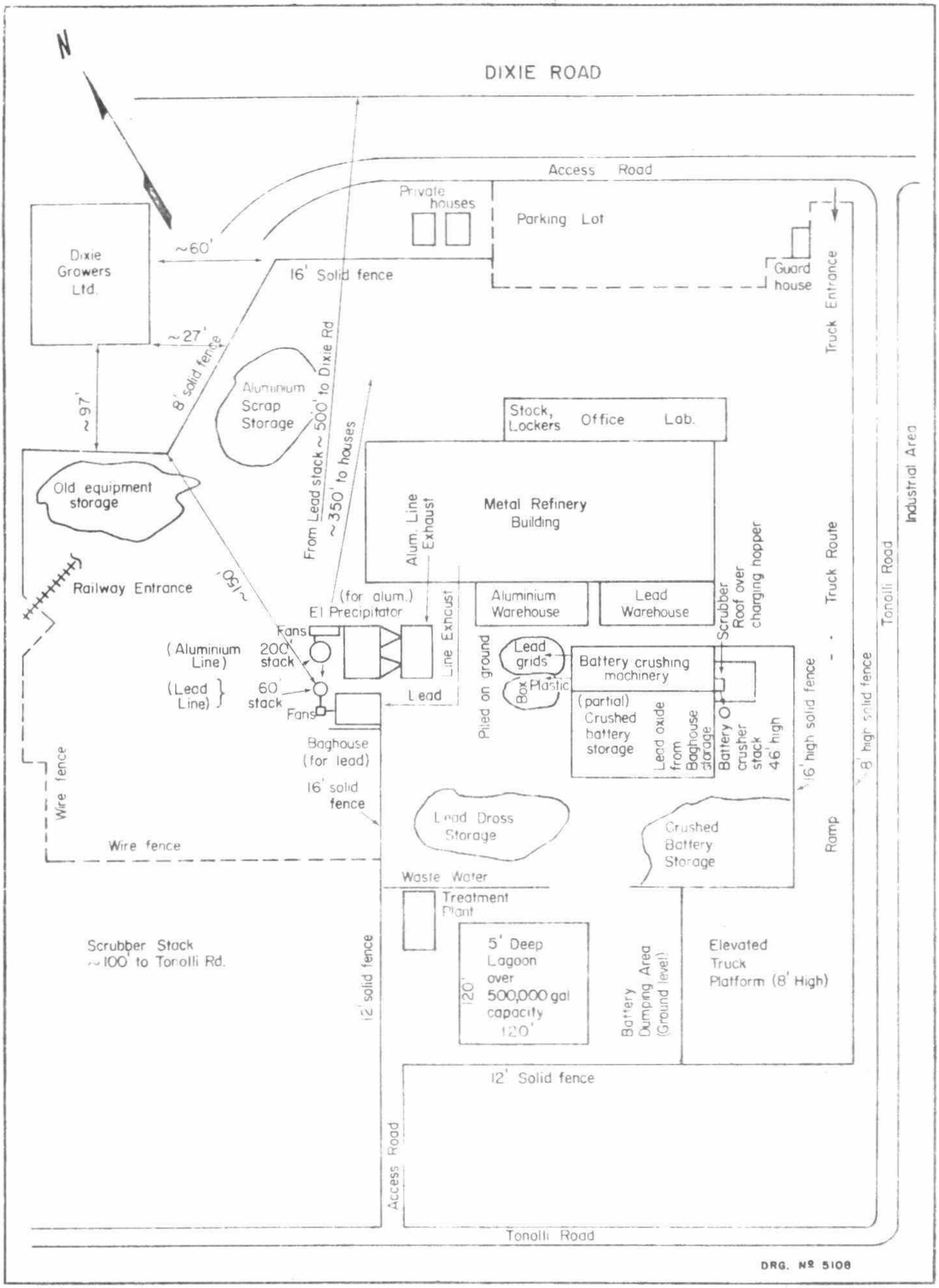
a) an 18-ft.-high wall was installed at the battery breaking area, and a truck-unload ramp was installed to separate lead dust from truck tires;

b) a door permanently closed in the lead dust storage and mixing building to reduce draft;

c) two additional sections added to the 12-section baghouse, thereby improving collection efficiency.

d) installed a wet scrubber on the battery crusher exhaust to control lead and sulphuric acid emissions.

After installation of new felted bags in the main baghouse in August 1974, the Company will stack sample this baghouse and the scrubber on the battery crusher operation.


N
DIXIE ROAD
Access Road
Private houses
Parking Lot
Guard house
Truck Entrance
Dixie Growers Ltd.
~60'
16' Solid fence
~27'
8' solid fence
~97'
Aluminium Scrap Storage
From Lead stack ~ 500' to Dixie Rd
~350' to houses
Stock, Lockers
Office
Lab.
Metal Refinery Building
Alum. Line Exhaust
Old equipment storage
~150'
Railway Entrance
(for alum.)
El Precipitator
Line Exhaust
Aluminium Warehouse
Lead Warehouse
Scrubber
Roof over charging hopper
Truck Route
Industrial Area
Tonolli Road
Fans
(Aluminium Line)
200' stack
(Lead Line)
60' stack
Fans
Lead
Piled on ground
Lead grids
Box Plastic
Battery crushing machinery
(partial) Crushed battery storage
Lead oxide from Baghouse storage
Battery crusher stack 46' high
16' high solid fence
8' high solid fence
Baghouse (for lead)
16' solid fence
Wire fence
Wire fence
Lead Dross Storage
Crushed Battery Storage
Ramp
Waste Water
Treatment Plant
Scrubber Stack ~100' to Tonolli Rd.
12' solid fence
5' Deep Lagoon over 500,000 gal capacity
120'
120'
Battery Dumping Area (Ground level)
Elevated Truck Platform (8' High)
12' Solid fence
Access Road
Tonolli Road
DRG. Nº 5108

6.4.3 Review of Plant Operations

The Company is a manufacturer of lead acid batteries for automotive vehicles

Lead oxide for the batteries is produced in a Harding rotary lead oxide mill, heated and kept in a constant elevated temperature by water sprays. The lead oxide is screened in an enclosed vibrating rotary screen which is exhausted outside through a bag collector. The lead oxide is then milled, conveyed to a filling area and filled into covered drums. The conveyors and filling operation are exhausted outside through a bag collector.

In 1973, the Company had installed an additional new oxide manufacturing facility complete with baghouses and stack.

The ground lead oxide is mechanically mixed with sulphuric acid to form a paste. The paste is transported by portable hoppers to two pasting machines and applied to battery grids.

The battery grids are cast in one of three casting machines. The molten lead and dross drum parts of the machines are hooded and exhausted to outside, and the grid casting parts are ventilated by general exhaust fans. Grids are dried in one of two gas-fired drying ovens which are vented to outside.

For wet charge batteries, the dried plates are separated and the lugs are buffed, separated, cleaned and scraped in various manually operated machines.

All of the above equipment is provided with local exhaust ventilation to outside.

The plates are stacked, with compressed paper spacers between the plates by two automatic stacking machines. The stacked plates are inspected. The stackers and inspection tables are provided with settling boxes and hoods which are vented to atmosphere. Next, the plates are assembled by welding at two automatic element assembly machines or manually at six tables. The automatic assembly equipment is vented directly outside. The assembled cell elements are set in battery cases at the two automatic machines and at two setting tables. The tables are vented to atmosphere. The wet charge batteries are then filled with electrolyte and conveyed to the charging area for precharging and then given a final charge. The charging area is vented to atmosphere. Sulphuric acid for paste and electrolyte are stored inside the plant building in two wooden tanks. The charged batteries are tested and placed on the shelves in the storage area.

For the dry-charge batteries, the dry pasted plates are charged by immersion in electrolyte in large open top tanks located in four forming rooms. The fumes from the charging tank area are vented to atmosphere.

The charged plates are washed with water in open top tanks and then dried in gas-fired ovens. Other than the combustion flue gases, these ovens are not vented to atmosphere.

The dried plates are then separated, cleaned, stacked and assembled at the same tables and machines used for the wet plates. The assembled batteries are tested and stored.

Since August 30, 1972, the Company has installed an additional new approved oxide manufacturing facility complete with baghouses and stack.

Emissions

There are 45 stacks and vents for this plant that may exhaust some quantity of lead or lead oxide fumes or particulate to atmosphere.

The Automatic Element Assembly area, the major potential source of lead emissions, is controlled by fabric filters.

In 1972 and 1973, some stacks or representative pieces of equipment on which no emission controls were installed, were tested. (See the attached Table 4 for a summary of results.)

Calculations based on the test results show that the aggregate emissions may result in concentrations in excess of the proposed standard of 10 $ug/m^3/30$ days.

6.4.4 Review of Abatement Activities - E.S.B.

1. An emission survey under Section 83 of the Act was conducted by the Ontario Ministry of the Environment during spring and summer 1972. The conclusions and recommendations of the Ministry were presented to the Company at a meeting on August 30, 1972. As a result, the Company was

required to take appropriate action to bring emissions into compliance with the Act and Regulations by August 31, 1974 in a staged program.

2. Since August 30, 1972, the Company has taken the following action:

a) installed a battery plate lug cleaning machine with a bag filter for emission control. This replaced an existing uncontrolled lug manufacturing operation and reduced the overall lead emissions from the plant.

b) modified ventilation of one plate breaking and lug cleaning table through the bag filter of the new machine.

c) conducted preliminary emission tests on a number of uncontrolled process stacks (see attached Table 4).

d) installed a demister to control fumes of sulphuric acid from two battery plate forming rooms. Other plate forming room exhausts will be fitted with similar units, subject to results from the first unit.

e) the old lead oxide manufacturing system will be served by a new stack, built for the new oxide manufacturing facility.

f) installed a 20,000 scfm baghouse with a 50-foot-high stack to control emissions from the Automatic Element Assembly, Winkle and Reed plate stackers, two hand plate stacking tables and one plate breaking table. The completion date was May 21, 1974.

3. The Company have made a commitment to install control equipment on the following operations by September 1974:

a) Winkle Box Element Assembly
b) Paste Mixing
c) Plate pasting and drying
d) Grid casting
e) Small parts casting
f) Intercell burning and post building

TABLE 6.4-1 STACK TEST RESULTS

METHOD	DATE	SOURCE	LEAD EMISSION RATE (lb/hr)
1	Dec/72	Reed Stacker	0.05
2	June 1/73	Reed Stacker	0.28*
1	Dec./72	#1 Grid Cast	0.13
2	May 29/73	#1 Grid Cast	0.01
1	Dec./72	Ground Lead Oxide	0.00 0.00
2	May 25/73	Ground Lead Oxide	0.05*
1	Dec./72	Winkel Stacker	0.07
2	May 26/73	Winkel Stacker	0.16
1	Dec./72	Auto-Element Assembly	0.38
2	May 23/73	Auto-Element Assembly	1.16
1	Dec./72	#4 Grid Cast	0.00
2	May 26/73	#4 Grid Cast	0.01

Method 1 - Testing performed by W.J. Hetrick, Philadelphia, using Company's own test method

Method 2 - Testing performed by J.G. Collinson, Mississauga, using AMB test method

* - Erroneously high since lead exceeds dust

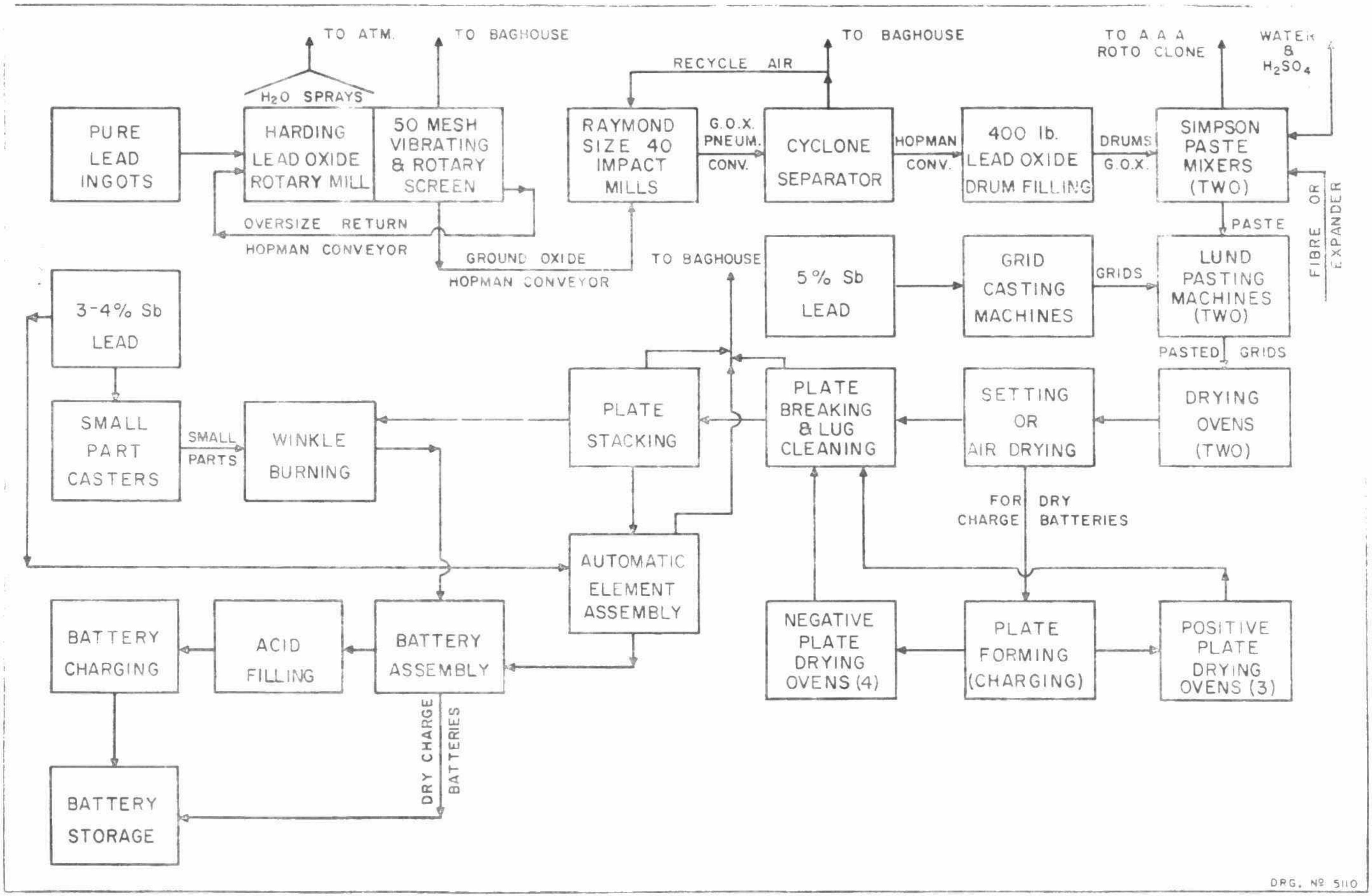
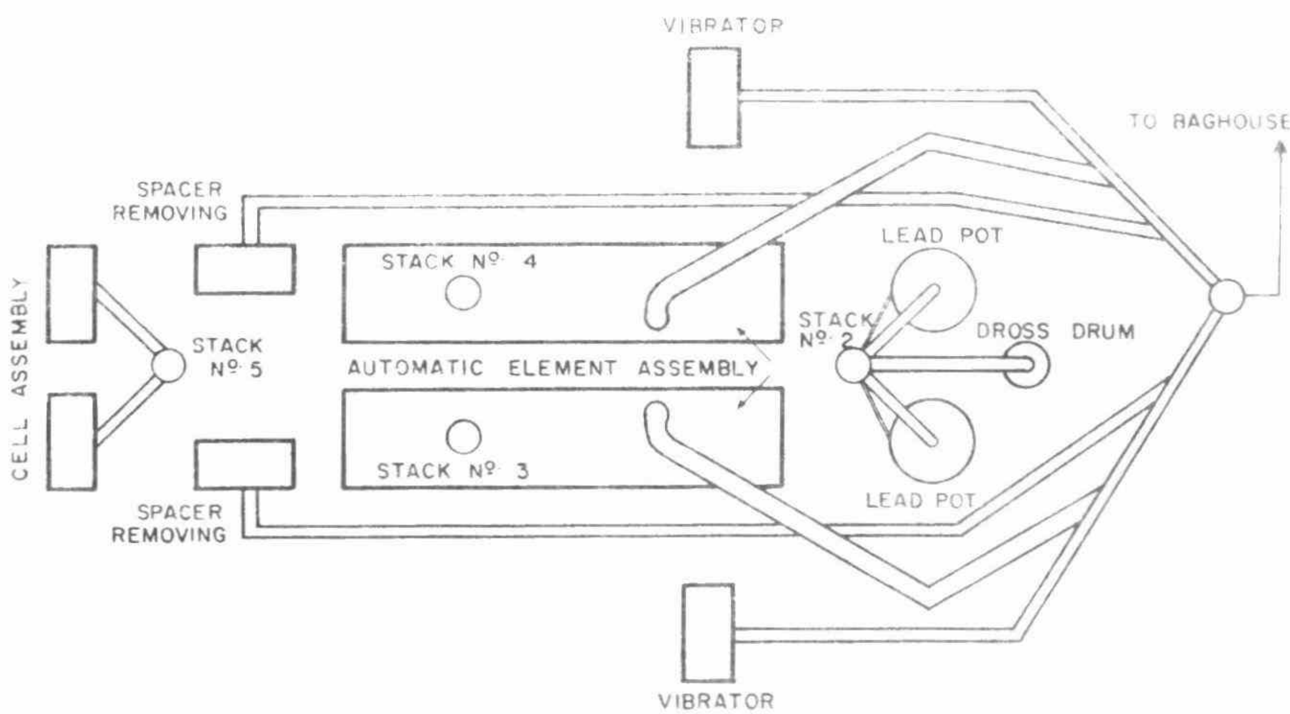


FIGURE - PROCESS FLOW DIAGRAM FOR ESB CANADA

ESB CANADA LTD.



LEGEND

FORMER STACK Nº 1 - TWO VIBRATORS; TWO ASSEMBLY SIDE HOODS; TWO SPACER REMOVING TABLES: NOW DIRECTED TO BAGHOUSE.

STACK Nº 2 - TWO LEAD POT HOODS; TWO HEATERS; ONE DROSS DRUM HOOD.

STACKS Nº 3 & 4 - ONE ASSEMBLY HOOD, EACH.

STACK Nº 5 - TWO CELL ASSEMBLY TABLES

DRG Nº 5111

FIG. - ESB CANADA LTD. – AUTOMATIC ELEMENT ASSEMBLY

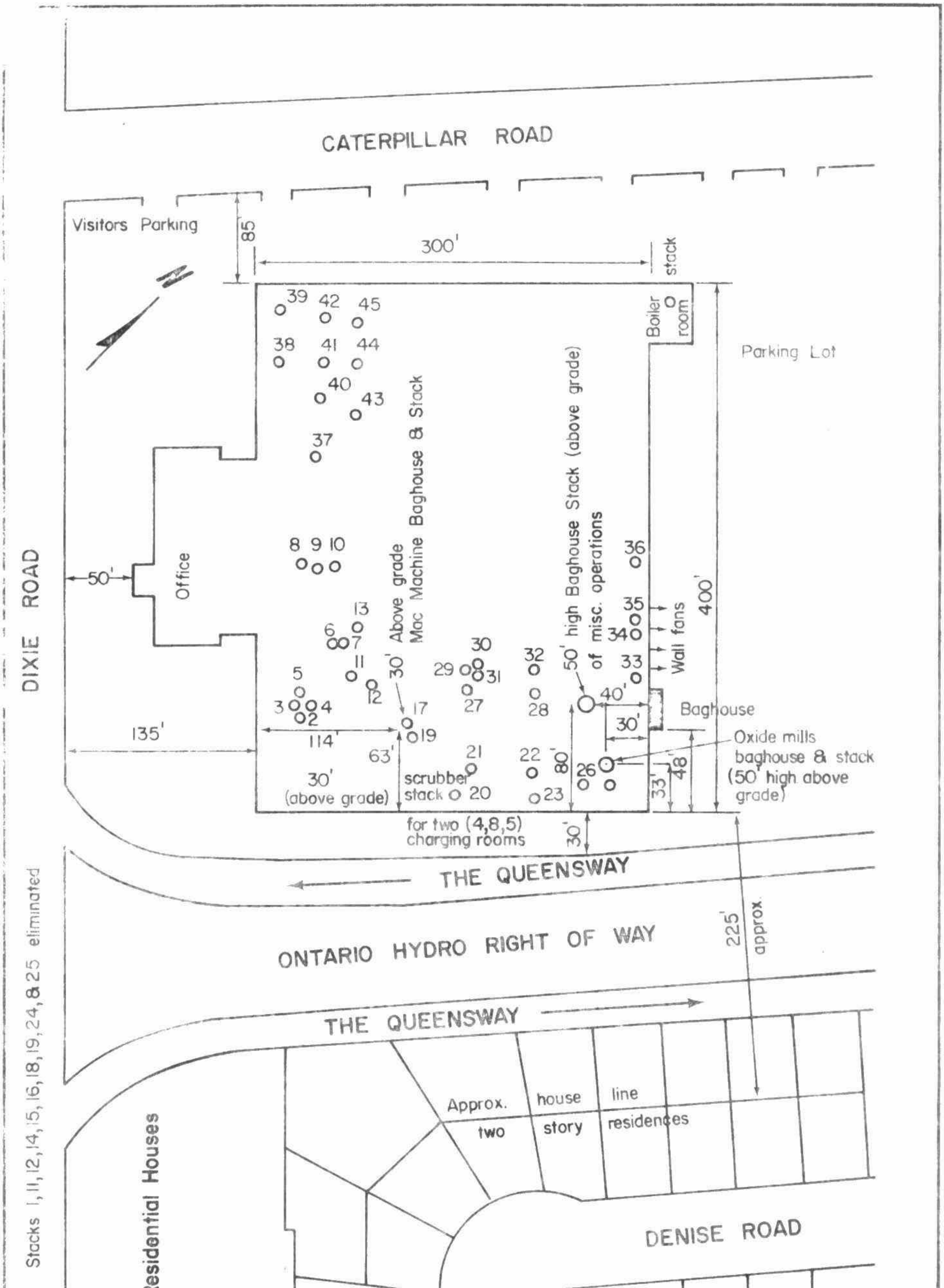


FIG. - PLAN VIEW FOR E.S.B. CANADA

6.4.5 [illegible] of Tonolli and [illegible] Plant

The sampling station locations in vicinity of the Tonolli and E.S.B. plants in Mississauga are shown in Figure [illegible]. A summary of the lead in suspended particulate matter [illegible] Table [illegible], and [illegible] Table [illegible] (b) and (c).

The lead in suspended particulate matter measured at Station No. 46046 exceeded the criterion of 15 ug/m^3 over 10% of the days sampled and the criterion of 5 ug/m^3 57% of the days sampled. At Station No. 46041, the lead level exceeded 15 ug/m^3 for 25% and 5 ug/m^3 5% of the days sampled, respectively. The maximum concentration of lead recorded at the two stations were 53 and 60 ug/m^3. Stations No. 46046 and 46041 are located on industrial property with No. 46046 on a roof of a building neighbouring the Tonolli property, and No. 46041 on the roof of the Guardhouse at the southeast entrance of the Tonolli plant and about 800 feet northwest of the E.S.B. plant. Correlation graphs shown in Figures 6.4.5-2 and 6.4.5-3 indicate significant correlations of lead levels with wind directions from the Tonolli property with some influence indicated with directions from the southeast, that is from the E.S.B. plant.

Suspended lead levels are lower at Station No. 46045 which is nearby the E.S.B. plant with concentrations exceeding 15 ug/m^3 2% of the days sampled, and 5 ug/m^3 10% of the days sampled. The maximum concentration recorded at this location was 20 ug/m^3. Suspended lead levels at this location correlate significantly with westerly winds which are from the direction of the Tonolli plant. (See

[illegible] No. [illegible] and No. [illegible] and on occasion at [illegible]tion No. 46045.

[illegible] lead in dustfall exceed Ontario's guideline of 0.30 tons per square mile per 30 days in the industrial area in close proximity to the plants but decrease to normal urban levels of less than 0.10 ton per square mile per 30 days in the residential areas.

Analysis of the size distribution of particles at Station 46041 in vicinity of the Tonolli plant indicates a high percentage of lead in the larger size particles, especially for measurements obtained when the winds are from the direction of the Tonolli plant. When the winds were from the direction of the E.S.B. plant and Dixie Road, the loadings were significantly lower and the average size of the lead particles was also lower. For winds in the direction of either plant, there was a difference in size distribution with that obtained from only traffic generated lead measurements as indicated in Figure 6.4.5-5.

TABLE 6.4.3-I

TONOLLI AND E.S.B. PLANTS
LEAD LEVELS IN SUSPENDED PARTICULATE MATTER

Station No.	Location Name	Location Description	Period Sampled	No. of Days Sampled	Geom. Mean $\mu g/m^3$	Maximum Conc. $\mu g/m^3$	No. of Days Conc. $>5\ \mu g/m^3$	% of Days Conc. $>5\ \mu g/m^3$	No. of Days Conc. $>15\ \mu g/m^3$	% of Da[illegible] Conc. >15 µg/[illegible]
46041	2414 Dixie Road	SE Corner of Tonolli 800' NW of ESB	4/10/73 to 30/3/74	89	7.49	60	51	57	23	25
46045	2365 Dixie Road	600' East of Tonolli 300' NW of ESB	13/12/73 to 30/3/74	100	3.00	20	10	10	2	2
46046	2360 Dixie Road	300' S of Tonolli 1,100' W of ESB	20/13/73 to 31/3/74	103	7.16	53	53	53	11	11

TABLE 6.4.3-II(a)

TOTAL LEAD IN DUSTFALL

1 9 7 2 TONS PER SQUARE MILE PER MONTH

STATION	LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
46008	1329 Kendall Mississauga		.22	.16	.16	.27	.16	.03	.02	.06	.06	.21	.11	.13
46009	Venta/Denise		.16	.30	.23	.16	.16	.07	.02	.06	.20	.03	.13	.14
46010	6 Dundix Road		.09	.04	.90	.04	.05	.03	.00	.03	.05	1.04	.01	.21
46011	St. Edmunds PS.		.26	.21	.24	.22	.13	.03	.01	.03	.04	.15	.11	.13
46016	1364 Dundas St. E.		.13	.10	.12	.14	.16	.05	.07	.07	.02	.06	.03	[illegible]
46041	Dixie Road		1.52	2.09	1.79	1.43	2.14	3.18	.92	1.69	2.05	2.09	1.33	[illegible]
46004	1480 Dundas East rear		.08	.04	.14	.07	.15	.09	.03	.05	.04	Discontinued		[illegible]

TABLE 6.4.3-II(b)

TOTAL LEAD IN DUSTFALL

1 9 7 3 TONS PER SQUARE MILE PER MONTH

STATION	LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	MEAN
46008	1329 Kendall Mississauga	.08	.16	.12	.10	.09	.11	.14	.13	.14	.24	.16	.17	.14
46009	Venta/Denise	.08	.03	.11	.16	.09	.36	.35	.19	.10	.57	.52	.16	.23
46010	6 Dundix Road	.02	.09	.02	.12	.07	.07	Msg.	.03	.20	.07	.07	.04	.07
46011	St. Edmunds PS.	Invalid	.20	.04	.14	.16	.09	.04	.04	.12	.14	Invalid	.15	.14
46016	1364 Dundas St. E.	.05	.08	.04	.06	.40	.10	.09	.06	.11	.15	.05	.06	.10
46041	Dixie Road	3.83	.50	.79	1.18	1.09	1.63	1.88	2.98	1.03	2,13	2.11	1.51	1.72

TABLE 6.4.3-II(c)

TOTAL LEAD IN DUSTFALL

1 9 7 4 TONS PER SQUARE MILE PER MONTH

ION	LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.
08	1329 Kendall Mississauga	Invalid	.19	.17	.22	.10							
09	Venta/Denise	Invalid	.39	.12	.37	.14							
10	6 Dundix Road	.01	.06	.04	.04	.04							
11	St. Edmunds PS.	.20	.11	.08	Invalid	Invalid							
6	1364 Dundas St. E.	.07	.07	.07	.08	.12							
1	Dixie Road	.33	.98	1.20	2.32	1.30							
5	2365 Dixie Road	.20	.63	.90	1.33	1.72							

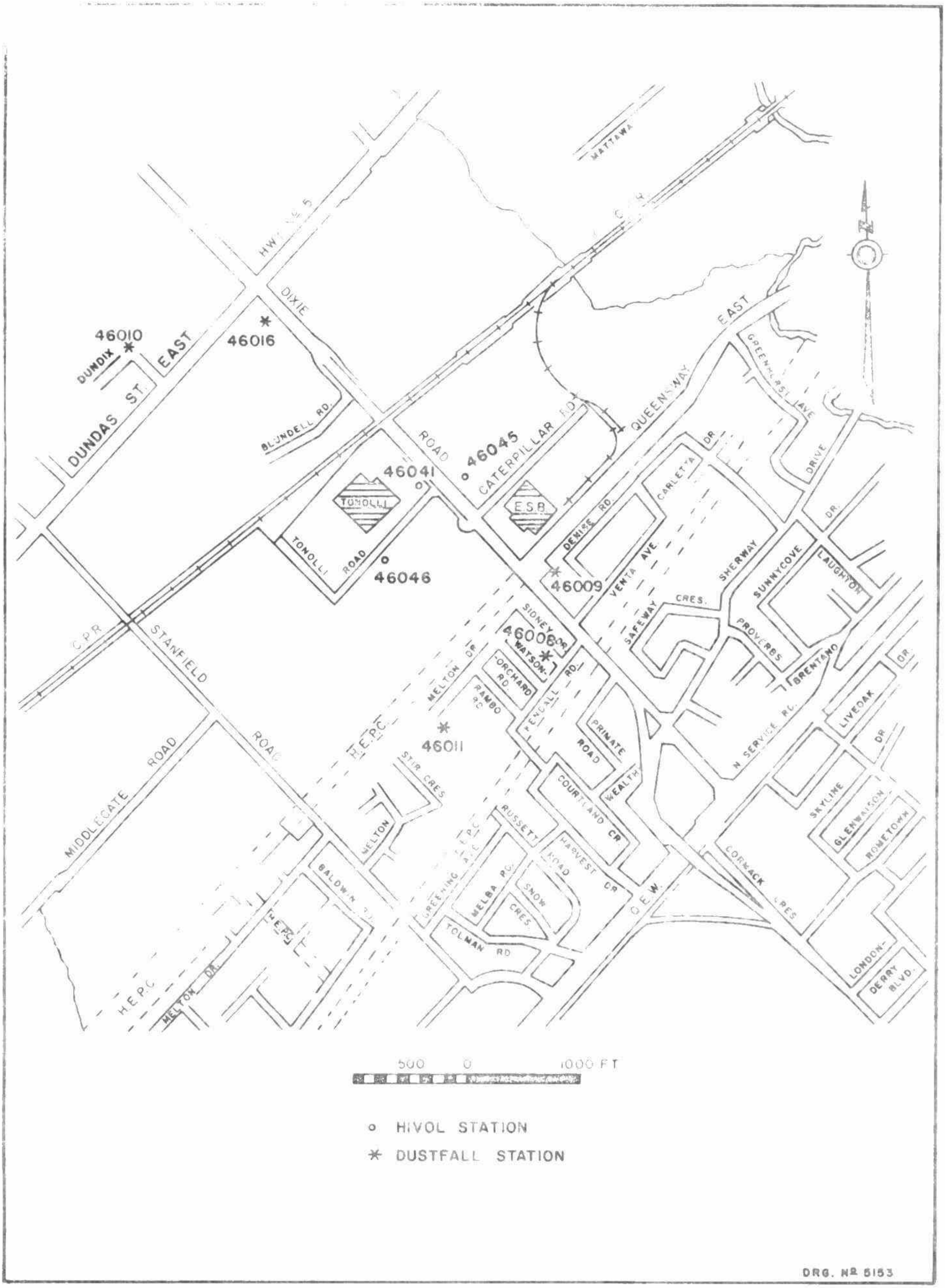
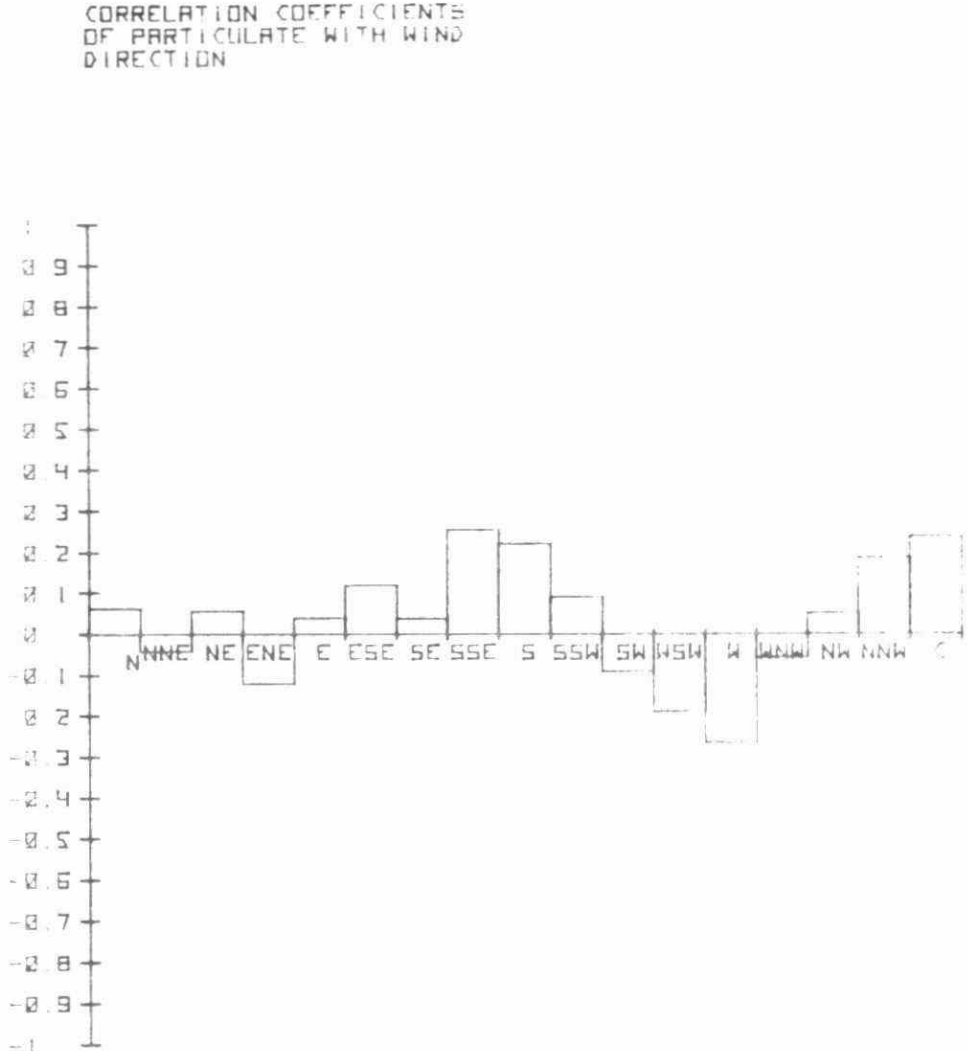


FIG. 6.4.3.-1 TONOLLI SURVEY – HIGHVOL AND DUSTFALL STATIONS.

FIG. 6.4.3-2


CORRELATION COEFFICIENTS
OF PARTICULATE WITH WIND
DIRECTION
N NNE NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW C

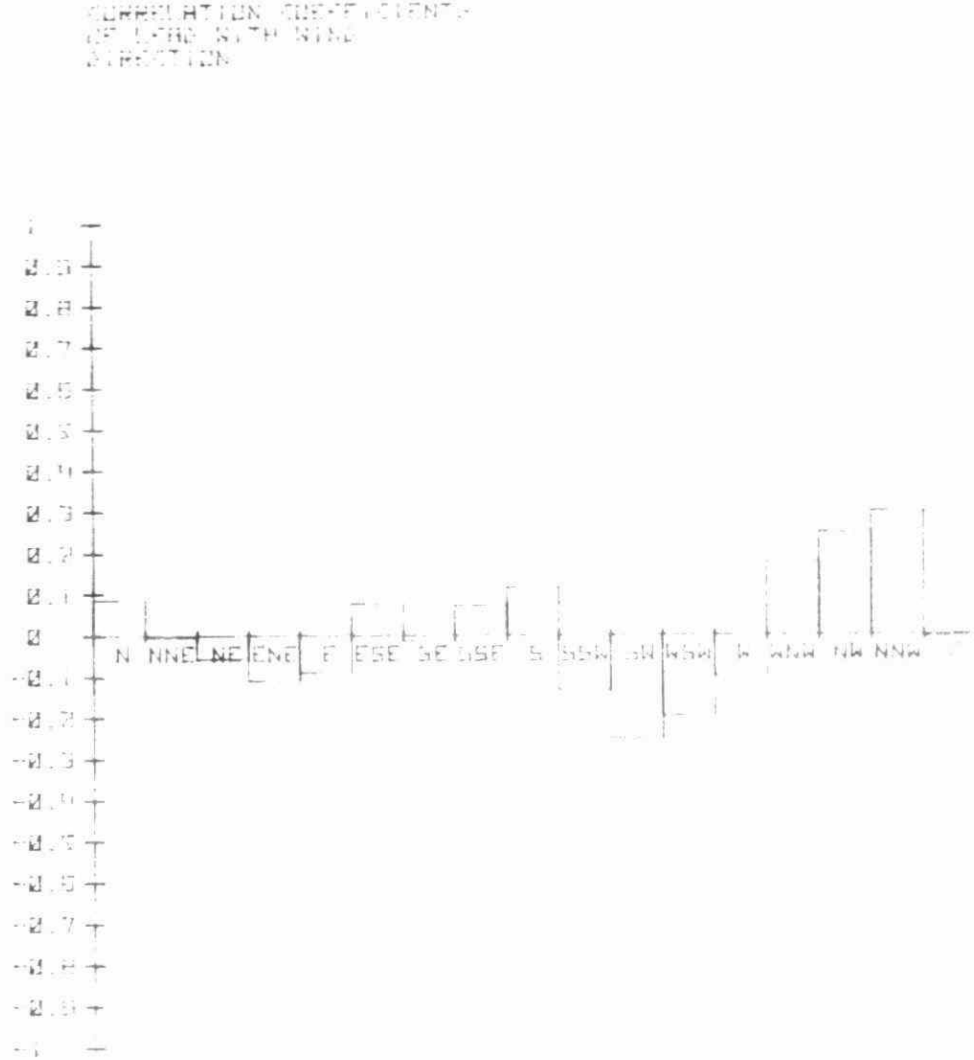
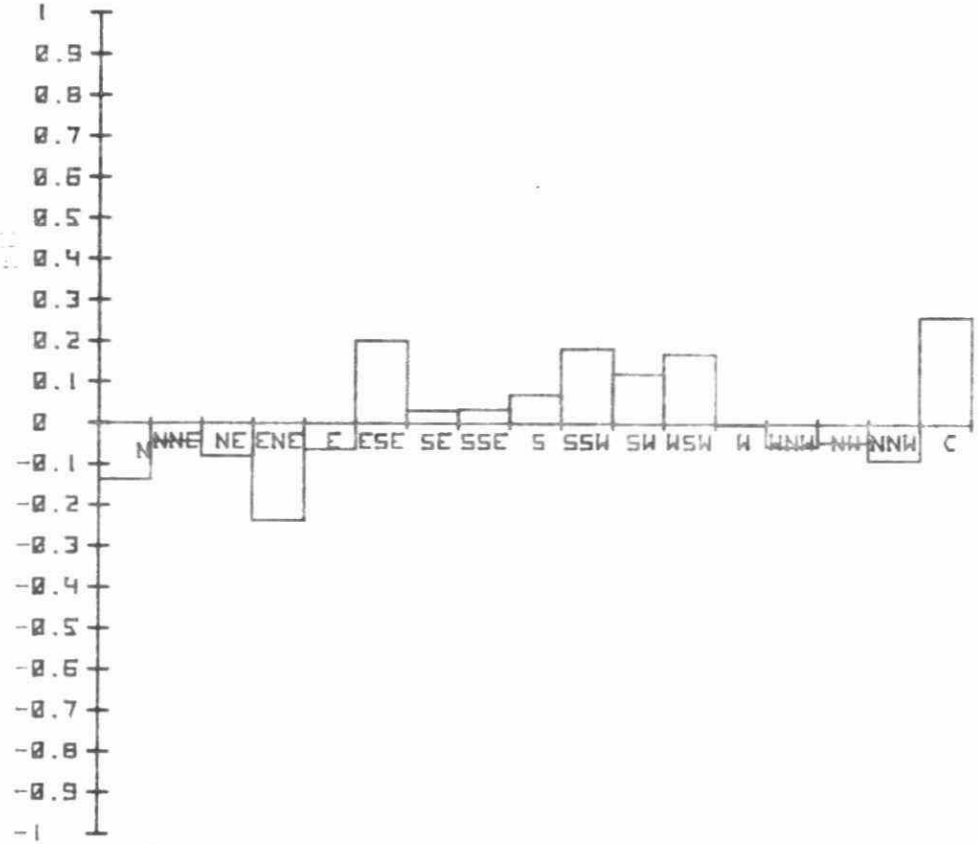

N NNE NE ENE E ESE SE SSE S SSW SW WSW W WNW NW NNW

FIG. 6.4.3-3 STATION NO 46041 89 READINGS

CORRELATION COEFFICIENTS
OF PARTICULATE WITH WIND
DIRECTION



CORRELATION COEFFICIENTS
OF LEAD WITH WIND
DIRECTION

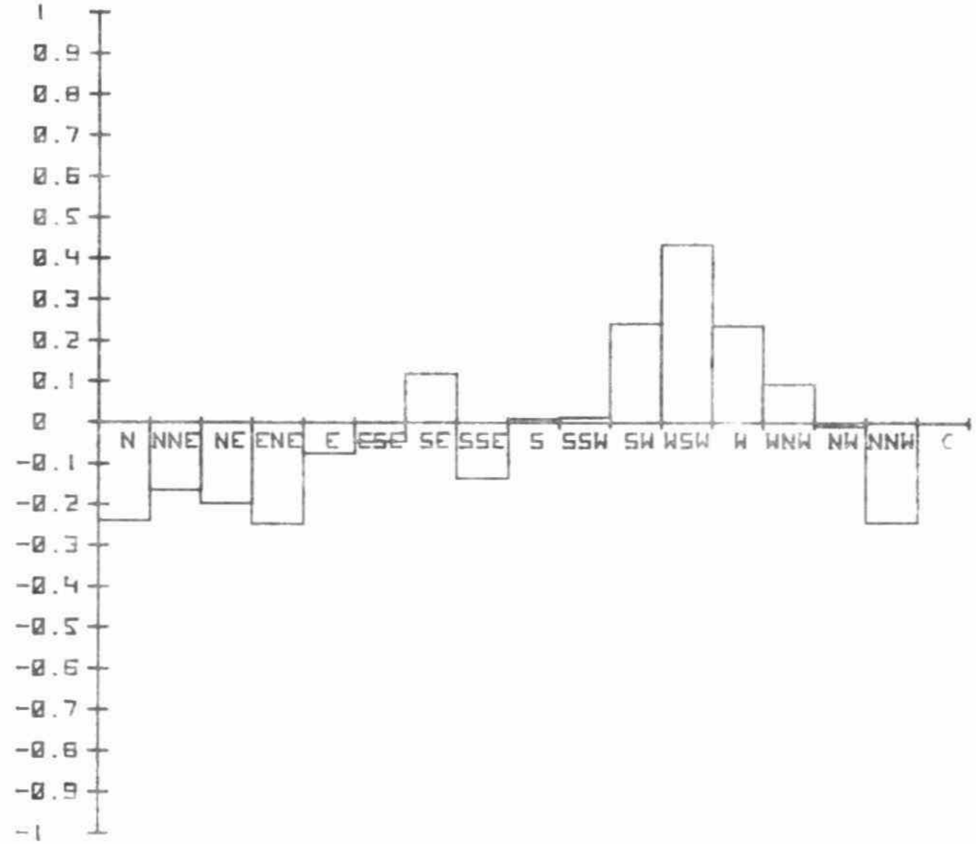
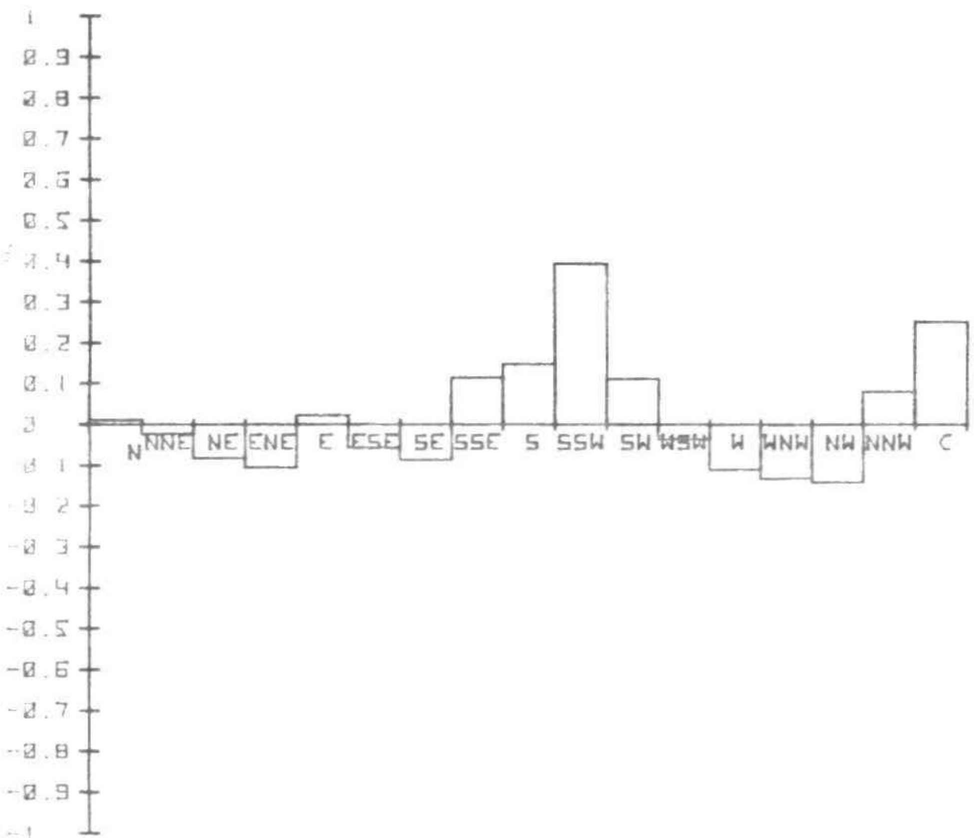
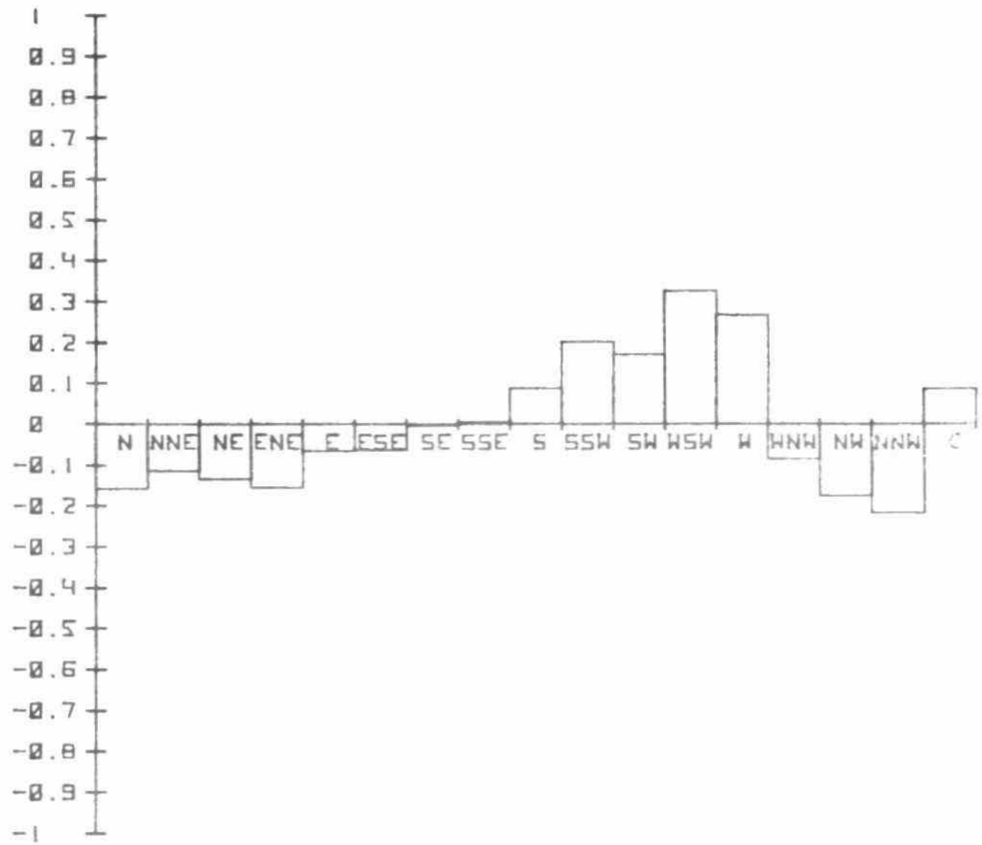


FIG. 6.4.3-4 STATION NO 46045 100 READINGS

CORRELATION COEFFICIENTS OF PARTICULATE WITH WIND DIRECTION



CORRELATION COEFFICIENTS OF LEAD WITH WIND DIRECTION



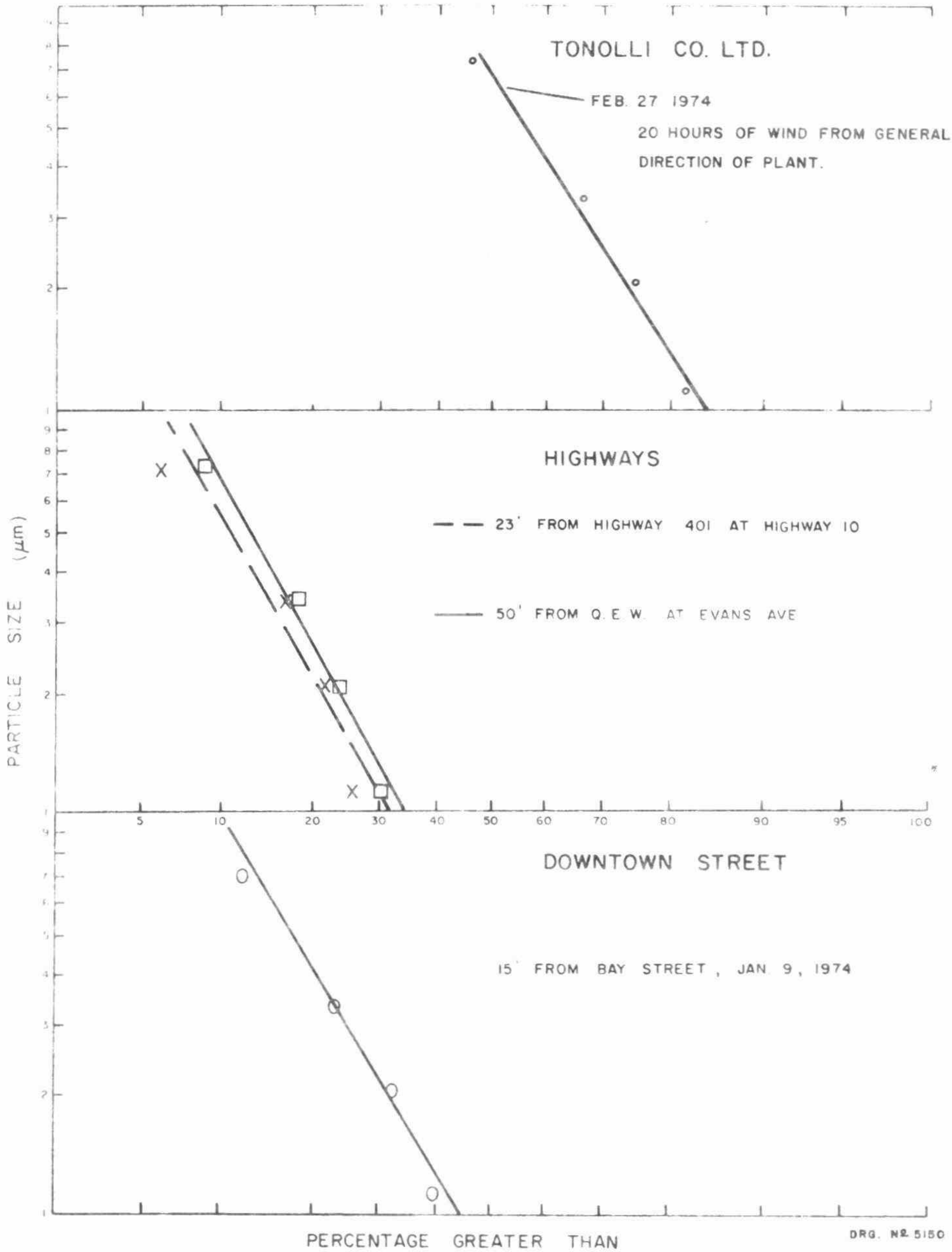


FIG. 6.4.3-5 TYPICAL PARTICLE SIZE DISTRIBUTION FOR LEAD NEAR STREETS, HIGHWAYS, & TONOLLI CO. LTD.

6.4.6 Summary of Lead Levels in Soil and Vegetation in the Vicinity of Tonolli Co. of Canada Ltd. (2414 Dixie Rd.) and ESB Canada Ltd. (2301 Dixie Rd.), Mississauga

The key conclusions of phytotoxicology assessment surveys conducted in the vicinity of Tonolli and ESB in 1970, 1971, 1972 and 1973 are:

1. On August 14, 1970, vegetation and soil were collected for lead chemical analysis at distances of 1000, 2000 and 3000 feet in each of four directions from the intersection of Tonolli and Dixie Roads, Mississauga. At this intersection, soil and vegetation were found to contain extremely high levels of lead (over 5000 and 2000 ppm, based on dry weight, respectively). Elevated levels of lead were found at distances of 1000 feet north, west, and east of the intersection.

2. The 1970 survey was repeated on July 8, 1971. Extremely high levels of lead were found in both soil and vegetation in 1971 at the same locations as were detected in 1970.

3. Since lead arsenate had been used by apple tree growers in the general area of Tonolli and ESB, the results for both lead and arsenic in soil and vegetation were closely examined. It was found that lead arsenate usage had little effect in the area and that both lead and arsenic contamination of soil and vegetation in the vicinity of Tonolli and Dixie Road were the result of industrial operations.

4. The phytotoxicology assessment survey in the vicinity of Tonolli and ESB was repeated on August 29, 1972. The results showed an increase in both lead and arsenic contamination of soil and vegetation within a 1000 foot arc of the Tonolli and Dixie Road intersection.

5. On August 30, 1973, the soil and vegetation lead survey in the vicinity of Tonolli and ESB was continued. A decrease in lead contamination was detected in 1973. Although a greater degree of lead contamination was found to occur immediately adjacent to Tonolli, the influence from ESB is significant because of the higher density of residential properties occurring immediately south and east of ESB.

Descriptions of these surveys follow, which include sampling locations, analyses results and their interpretation.

6.4.6.1 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - August 14, 1970

Description of Investigation

The survey consisted of examining vegetation and collecting soil and vegetation samples for chemical analysis at distances of 1000, 2000 and 3000 feet on each of four directions - west, north, east, and south from the intersection of Tonolli And Dixie Roads, Mississauga, in the vicinity of Tonolli and ESB. In addition, fruit and vegetable growing areas within this 3000-foot arc were examined. (See attached Figure.)

Station 0 was established at the intersection of Dixie Road and Tonolli Road, immediately south of the Tonolli Company of Canada. Soil was sampled at three different levels at each sampling station. These levels were the surface inch, the 1-4 inch layer, and the 7-9 inch layer. Grass samples were collected also at each station. Table 1 shows the results for lead contents in soil and grass at the established sampling stations.

At Station 0, vegetation and soil contained extremely high concentrations of lead. The top soil contained over 25 times the concentration normally found in soil. The grass samples had extremely high levels of lead also and contained over nine times more lead in unwashed samples than in washed samples. In the soil, 5200 ppm lead was found in the surface inch, 380 ppm in the 1-4 inch layer, and 180 ppm in the 7-9 inch layer. These values demonstrate the low solubility and immobility of lead.

Elevated concentrations of lead were found in the surface soil at distances of 1000 feet north, west, and east of Station 0. Lead contents in grass were somewhat elevated at these sampling stations.

Samples of soil, beet roots, and lettuce leaves were collected from a vegetable growing area north of Tonolli for chemical analysis. The results of these analyses are shown in Table 2. The concentrations of lead in the cultivated soil were normal. The concentrations of lead within the beet roots were within safe limits. The unwashed leaves of lettuce had concentrations of 19 to 22 ppm lead (based on dry weight), whereas washed leaves ranged from 6 to 12 ppm. These values demonstrate that the contamination of the vegetables by aerial deposition of lead compounds was mostly in the nature of a topical dust coating of which about 50 per cent could be removed by water washing.

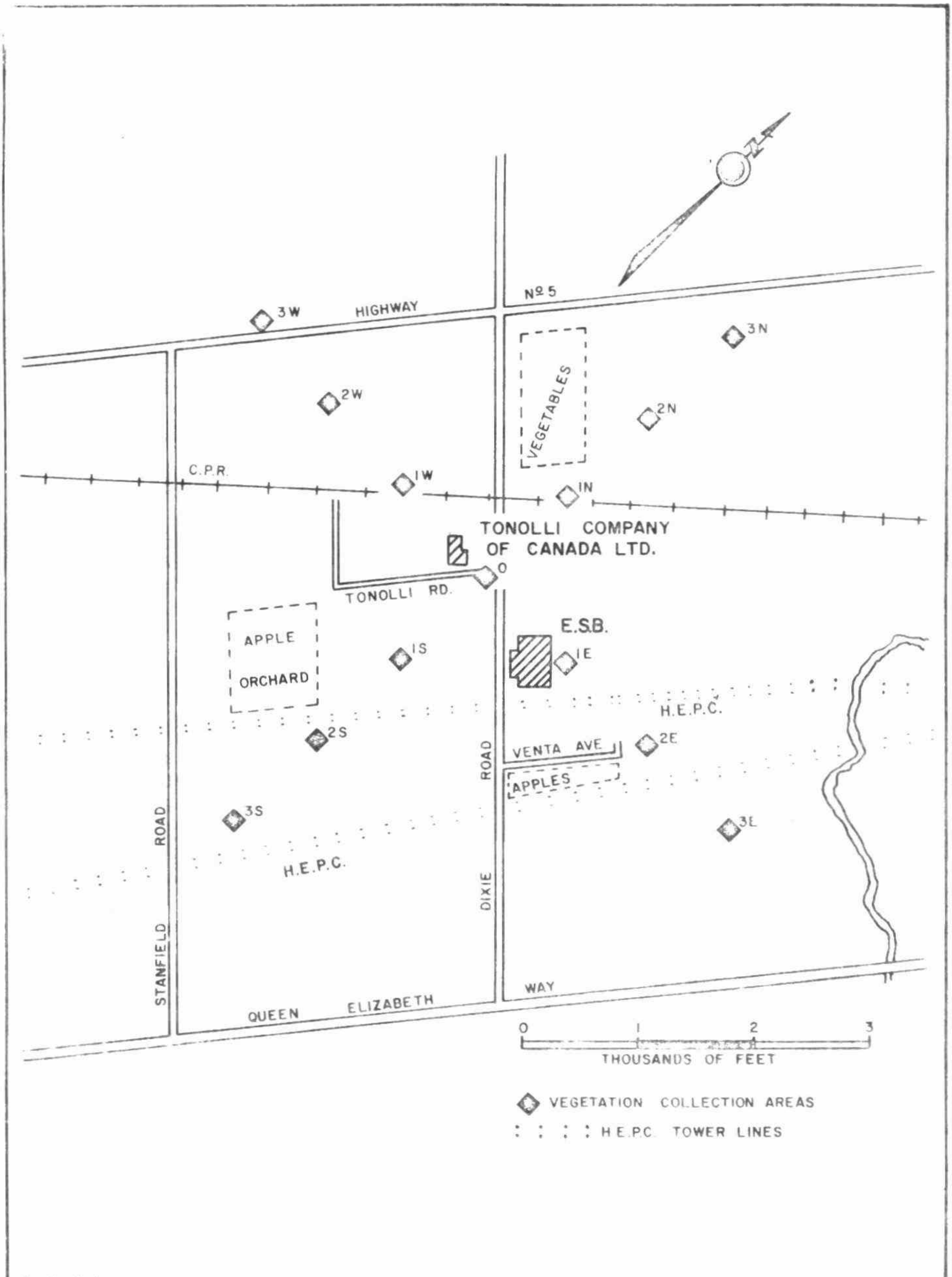


FIG. 1 - VEGETATION AND SOIL SAMPLING LOCATIONS, MISSISSAUGA - 1970

TABLE I

RESULTS OF CHEMICAL ANALYSES FOR LEAD IN SOIL AND GRASS

MISSISSAUGA AREA AUGUST 14, 1970.

STATION NUMBER	DISTANCE & DIRECTION FROM TONOLLI	TOTAL LEAD CONTENT (parts per million, based on dry weight)				
		Top Inch of Soil	1-4 Inch Layer	7-9 Inch Layer	Grass NW	Grass W
0	Intersection Tonolli Road & Dixie Road	5200	380	180	2020	227
1 N	1000 ft N	612	104	67	21	27
2 N	2000 ft N	140	73	63	5	5
3 N	3000 ft N	59	40	35	5	4
1 W	1000 ft W	450	88	37	12	12
2 W	2000 ft W	194	122	31	9	3
3 W	3000 ft W	283	122	88	10	12
1 E	1000 ft E	340	141	35	28	19
2 E	2000 ft E	185	53	27	18	7
3 E	3000 ft E	216	80	50	20	13
1 S	1000 ft S	136	21	29	12	8
2 S	2000 ft S	53	49	33	13	4
3 S	3000 ft S	81	44	78	3	2

NW = Not washed

W = Washed

TABLE 2

RESULTS OF CHEMICAL ANALYSES FOR LEAD IN SOIL AND VEGETABLES

MISSISSAUGA AREA AUGUST 14, 1970.

VEGETABLE AREA	LEAD (ppm, based on dry weight)					
	LETTUCE ROWS			BEET ROWS		
	Soil	Lettuce leaves		Soil	Beet roots	
		NW	W		NW	W
1200 ft NNW of Tonolli Company of Canada	60	19	6	76	11	4
1600 ft NNW of Tonolli Company of Canada	59	22	12	57	8	6

NW = Not washed

W = Washed

6.1.6.2 Phyto[illegible] Assessment [illegible] Soil and Vegetation July 8, 1971

Description of Investigation

A further investigation was conducted on July 8, 1971 in the vicinity of Tonolli Company of Canada Ltd., and ESB Canada Ltd. for the effects of lead emissions on soil and vegetation. Similar to the 1970 survey, collections were made at 1000, 2000 and 3000 feet in each of four directions - west, north, east, and south from the intersection of Tonolli and Dixie Roads, Mississauga. In addition, apple fruit and vegetables were sampled within this 3000 foot arc.

The results of the chemical analyses for lead in grass and soil are shown in Table 1. At Station 0, at the intersection of Tonolli and Dixie Roads, extremely high concentrations of lead were found in the soil and grass. The soil contained up to 25 times the concentration of lead normally found in soil. In addition, foliage collected from white ash and Austrian pine trees at this location contained lead concentrations ranging from 1080 to 8000 ppm. Normal concentrations are usually less than 15 ppm.

High levels of lead were found also in soil and grass at Station 1W, 1000 feet west of Station 0 and about 700 feet west of the Tonolli stack.

Vegetables collected near Stations 1N and 2N showed elevated lead levels in leaf lettuce. Cauliflower leaves and beet roots did not contain excess amounts of lead; however, washed leaf lettuce contained 34 ppm lead at Station 1N and 30 ppm lead at Station 2N, based on dry weight.

Apple fruit contained low levels of lead at all stations where it was sampled despite elevated concentrations of lead found in appletree foliage (Table 2).

TABLE 1

RESULTS OF CHEMICAL ANALYSES FOR LEAD IN SOIL AND GRASS

MISSISSAUGA AREA JULY 8, 1971

STATION NUMBER	DISTANCE & DIRECTION FROM TONOLLI & DIXIE ROADS	TOTAL LEAD CONTENT (parts per million, based on dry weight)				
		Top Inch of Soil	1-4 Inch Layer	7-9 Inch Layer	Grass NW	Grass W
0	Intersection Tonolli & Dixie Roads	3050	5000	295	3930	1840
1 W	1000 ft W	550	140	200	165	140
2 W	2000 ft W	194	176	42	27	17
3 W	3000 ft W	40	21	22	15	5
1 E	1000 ft E	36	52	180	46	51
2 E	2000 ft E	58	100	45	200	51
3 E	3000 ft E	180	100	45	50	23
1 S	1000 ft S	55	16	13	53	59
2 S	2000 ft S	107	71	40	20	11
3 S	3000 ft S	77	68	71	8	4
1 N	1000 ft N	35	29	14	17	11
2 N	2000 ft N	107	62	70	18	13
3 N	3000 ft N	35	31	29	8	7

NW = Not washed

W = Washed

TABLE 2

RESULTS OF CHEMICAL ANALYSES FOR LEAD
IN LEAVES AND FRUIT OF APPLE TREES

MISSISSAUGA AREA JULY 8, 1971

STATION NUMBER	DISTANCE & DIRECTION FROM TONOLLI & DIXIE ROADS	TOTAL LEAD CONTENT (parts per million, based on dry weight)			
		Leaves		Fruit	
		NW	W	NW	W
2 E	2000 ft E	234	101	8	6
1 S	1000 ft S	121	43	5	2
2 S	2000 ft S	91	57	2	2
3 S	3000 ft S	39	29	2	1

NW = Not washed

W = Washed

[illegible] [illegible] Arsenic in Soil and Vegetation [illegible] and 1971

The following report was prepared in reply to the question which had arisen concerning the use of lead arsenate by apple growers in the vicinity of Tonolli and ESB, Mississauga, and its contribution to the lead contamination detected in soil and vegetation in the vicinity of the industries in 1970 and 1971.

Lead Arsenate

Acid type lead arsenate ($Pb\ H\ AsO_4$) is marketed as a wettable powder (100% active ingredient) and is one of the chemicals recommended by the Ministry of Agriculture and Food for apple maggot insect control in apple orchards. It should be applied twice during the development of the fruit. The first application should take place during the first week of July, with the second not later than July 20. At each application, 2.5 pounds of lead arsenate are mixed with 100 gallons of water. Approximately 400 gallons of this material are applied to one acre of 20-foot-high apple trees (less spray volume for smaller trees). Thus, approximately 10 pounds of lead arsenate (6.0 pounds of lead and 2.2 pounds of arsenic) are applied per acre at each application. The spray solution of lead arsenate (2.5 pounds per 100 gallons water) is equivalent to 1490 ppm lead and 540 ppm arsenic. A basic type of lead arsenate, $Pb_4\ (PbOH)\ (AsO_4)_3$ is also available for insecticidal use in apple orchards. This material is safer to succulent foliage as the basic nature averts the formation of arsenic acid (H_3AsO_4), a phytotoxic compound that results from the reaction of the acidic lead arsenate and water. Despite the lowered phytotoxicity, this material is infrequently used by apple growers. In order to avoid exceeding the 2.0 ppm

arsenic tolerance for apple fruit established by the Canada Department of National Health and Welfare, lead arsenate should not be applied within 45 days of apple harvest. Although lead arsenate is one of the recommended insecticides for the control of apple maggots, it is not the most widely used. Organophosphorus compounds such as azinphos-methyl (Guthion) and Imidan (no common name) have generally replaced lead arsenate in the spraying schedule as they are usually more effective and provide a wider spectrum of insect control. The owner of a farm supply store in the vicinity of Dixie Road and Dundas Street West stated that he had sold only about 10 cases of lead arsenate in 1971. As one case weighs 48 pounds, approximately 500 pounds of lead arsenate, enough for 25 acres, was distributed. The owner said that the lead arsenate sales were to older farmers with small orchards.

Lead Analyses Results

The chemical analyses results for lead in soil and forage (grass) collected in the vicinity of Tonolli and ESB, Mississauga, on August 14, 1970 and July 8, 1971, were given in Sections 6.4.6.1 and 6.4.6.2. The lead content of the foliage and fruit of apple trees sampled in the vicinity of the industries in 1970 and 1971 are shown in Table 1.

The lead content of apple leaves collected from orchards and isolated backyard trees in the vicinity of Tonolli and Dixie Roads in 1970 and 1971 was notably higher than the lead content of the corresponding grass samples. This phenomenon is probably related to the densely pubescent nature of the apple leaves which would have a greater tendency to accumulate and retain lead particles. In both years the lead content of all apple leaf samples decreased with increasing

distance from the inte[illegible] samples from old non-productive orchards located near the industries consistently displayed higher lead contamination than insecticide-treated productive orchards located farther away.

In one case, apple leaf samples were collected from two locations (1000 feet south and 2000 feet south) in the same productive orchard. Despite the fact that these trees would probably have received the same chemical treatment, the lead content of the leaves collected nearest the industries was 2.3 and 1.3 times higher in 1970 and 1971 respectively, than the corresponding samples collected 2000 feet south.

Arsenic Analyses Results

The chemical analyses results for arsenic in soil and forage (grass) collected in the vicinity of the battery manufacturing and lead recovery industries on August 14, 1970 and July 8, 1971 are shown in Tables 2 and 3, respectively. The arsenic content of the foliage and fruit of apple trees samples in the vicinity of the industries in 1970 and 1971 is shown in Table 4.

Elevated arsenic levels were detected in grass samples collected at the intersection of Tonelli and Dixie Roads in 1970 and 1971. Grass samples collected at all other locations in 1970 contained less than 1 ppm arsenic. In 1971, with two exceptions, the grass samples collected at locations other than Station 0 contained 2 ppm arsenic or less. The exceptions were at 1000 feet west and 2000 feet east. The elevated arsenic level detected in grass 1000 feet west of the intersection coincided with high lead levels in the soil and grass. This grass was collected

from a backyard in a residential area, and could have been treated with an organic arsenical for crabgrass weed control.

Soil samples collected in 1970 and 1971 contained levels of arsenic that ranged from 0.5 - 35.8 ppm and 1.6 - 45.2 ppm, respectively. There was no apparent relationship between the levels of arsenic in the soil and the sampling distance from the intersection of Tonolli and Dixie Roads. In both years, the highest soil arsenic levels were obtained 2000 feet west of the intersection, in a small, non-productive old orchard. The arsenic detected in the soil at this location is probably of a residual nature as a result of the excessive use of lead arsenate in the past. In 1947, farmers were advised to apply approximately 120 pounds of lead arsenate per acre per year.

The arsenic content of apple leaf samples collected in 1970 and 1971 was slightly higher than the respective grass samples. As was the case with lead, the arsenic content of the apple leaf samples decreased with distance from the intersection of Tonolli and Dixie Roads. In no case, in either 1970 or 1971 did the arsenic content of the apple fruit exceed the 2.0 ppm arsenic tolerance level. The lead arsenic ratio of the apple leaf samples ranged from 66: 1 to 516: 1 in 1970 and from 22: 1 to 102: 1 in 1971. These ratios are far in excess of the 3: 1 ratio that would have resulted from the analysis of leaves sprayed with lead arsenate.

It can be concluded that the usage of lead arsenate as a control for insects in apple orchards had little effect in the area and that both lead and arsenic contamination of soil and vegetation in the vicinity of Tonolli and Dixie Roads were the result of industrial operations.

TABLE 1

RESULTS OF CHEMICAL ANALYSES FOR LEAD IN LEAVES AND FRUIT OF APPLE TREES

MISSISSAUGA AREA AUGUST 14, 1970 JULY 8, 1971

Distance & Direction from Tonolli & Dixie Roads	Type of Orchard	Total Lead Content (parts per million, based on dry weight)							
		Leaves				Fruit			
		Not Washed		Washed		Not Washed		[illegible]	
		1970	1971	1970	1971	1970	1971	[illegible]	[illegible]
2000 feet W	non-productive old orchard	205	218	112	158	-	-	-	-
1000 feet E	non-productive old orchard	258	412	128	212	-	-	-	-
2000 feet E	productive orchard	-	234	-	101	2	6	4	[illegible]
1000 feet S	productive orchard	177	121	81	43	6	5	5	[illegible]
2000 feet S	same orchard as 1000 feet S	77	91	40	57	1	2	<0.5	2
3000 feet S	backyard apple tree	49	39	21	29	-	2	-	1

TABLE 2

RESULTS OF CHEMICAL ANALYSES FOR ARSENIC IN SOIL AND GRASS

MISSISSAUGA AREA AUGUST 14, 1970

STATION NUMBER	DISTANCE & DIRECTION FROM TONOLLI	TOTAL ARSENIC CONTENT (parts per million, based on dry weight) Top Inch of Soil	1-4 Inch Layer	7-9 Inch Layer	Grass NW	Grass W
0	Intersection Tonolli Road & Dixie Road	6.6	2.0	1.8	12.4	9.8
1 N	1000 ft N	4.6	4.2	<0.5	<0.5	<0.5
2 N	2000 ft N	23.8	19.6	15.0	<0.5	<0.5
3 N	3000 ft N	9.8	4.2	2.6	<0.5	<0.5
1 W	1000 ft W	10.6	5.2	4.2	0.6	<0.5
2 W	2000 ft W	35.6	20.6	6.4	0.6	<0.5
3 W	3000 ft W	8.6	5.0	4.4	<0.5	<0.5
1 E	1000 ft E	27.2	23.4	16.4	<0.5	<0.5
2 E	2000 ft E	6.0	5.0	2.2	<0.5	<0.5
3 E	3000 ft E	15.2	8.8	5.8	<0.5	<0.5
1 S	1000 ft S	4.4	2.2	1.4	<0.5	<0.5
2 S	2000 ft S	4.0	3.4	2.0	0.9	<0.5
3 S	3000 ft S	14.0	12.0	11.6	<0.5	<0.5

NW = Not washed

W = Washed

TABLE 3

RESULTS OF CHEMICAL ANALYSES FOR ARSENIC IN SOIL AND GRASS

MISSISSAUGA AREA JULY 8, 1971

STATION NUMBER	DISTANCE & DIRECTION FROM TONOLLI & DIXIE ROADS	TOTAL ARSENIC CONTENT (parts per million, based on dry weight)				
		Top Inch of Soil	1-4 Inch Layer	7-9 Inch Layer	Grass NW	Grass W
0	Intersection Tonolli & Dixie Roads	18.0	13.8	6.8	27.2	21.1
1 N	1000 ft N	6.8	7.2	4.6	<0.5	<0.5
2 N	2000 ft N	18.4	16.0	19.8	1.2	<0.5
3 N	3000 ft N	8.6	8.0	8.2	<0.5	<0.5
1 W	1000 ft W	13.2	7.2	7.2	7.5	4.8
2 W	2000 ft W	45.2	43.6	15.0	1.9	0.8
3 W	3000 ft W	4.0	4.6	4.6	1.8	0.6
1 E	1000 ft E	9.6	9.6	9.6	1.8	1.8
2 E	2000 ft E	18.0	16.6	10.0	4.8	3.6
3 E	3000 ft E	4.6	4.8	1.6	2.0	1.8
1 S	1000 ft S	6.4	4.0	4.0	2.0	1.8
2 S	2000 ft S	9.6	9.8	3.8	0.8	0.8
3 S	3000 ft S	13.4	14.4	15.2	1.0	<0.5

NW = Not washed

W = Washed

TABLE 5

RESULTS OF CHEMICAL ANALYSES FOR ARSENIC IN LEAVES AND FRUIT OF APPLE TREES

MISSISSAUGA AREA AUGUST 14, 1970 JULY 8, 1971

Distance & Direction from Tonolli & Dixie Roads	Type of Orchard	Total Arsenic Content (parts per million, based on dry weight)							
		Leaves				Fruit			
		Not Washed		Washed		Not Washed		Washed	
		1970	1971	1970	1971	1970	1971	1970	1971
2000 feet W	non-productive old orchard	<0.5	4.3	<0.5	2.3	-	-	-	-
1000 feet E	non-productive old orchard	<0.5	5.0	<0.5	2.4	-	-	-	-
2000 feet E	productive orchard	-	2.3	-	1.2	0.9	<0.5	0.8	<0.5
1000 feet S	productive orchard	2.7	3.5	2.7	2.0	<0.5	0.9	<0.5	0.8
2000 feet S	same orchard as 1000 feet S	<0.5	2.7	<0.5	2.4	0.5	1.0	<0.5	0.6
3000 feet S	backyard apple tree	<0.5	1.8	<0.5	0.8	-	<0.5	-	<0.5

6.4.6.4 1972 Phytotoxicology Assessment Survey for Lead in Soil and Vegetation - August 29, 1972

Description of Investigation

On August 29, 1972, the vegetation and soil surveillance investigation was continued in the vicinity of the Tonolli and ESB plants, Mississauga. In order to more clearly define the areas of lead contamination with respect to emissions from the two sources, additional sampling stations were established in close proximity to ESB, at distances of 5 and 400 feet northeast.

Lead

Extremely high levels of lead were detected in the 1972 samples of soil and grass collected at the intersection of Tonolli and Dixie Roads. High levels of lead also were detected in the grass and soil up to 1000 feet to the east and west of the intersection of Tonolli and Dixie Roads. There appears to have been a gradual elevation in the levels of lead occurring within the 1000-foot arc of the area under surveillance.

The lead analyses results for the two additional stations established to the northeast of ESB are shown in Table 1. These results indicate that the ESB plant has contributed to the overall lead problem in this area.

Arsenic

High levels of arsenic were detected in the 1972 samples of grass and surface soil at the intersection of Tonolli and Dixie Roads (Station 0). Considerably

lower but nevertheless elevated levels of arsenic were detected also in the surface soil and grass 1000 feet west of Station 0. Normal and variable levels of arsenic were detected in grass and soil at all other sampling locations. A comparison of the data for three consecutive years on arsenic levels of grass and surface soil at station 0 and 1000 feet west indicates that there has been a gradual increase in the severity of the arsenic contamination in this area.

As was the case with lead, the grass and soil collected immediately northeast of the ESB plant were found to be affected by arsenic emissions (Table 1).

Apple Analyses Results

Levels of lead and arsenic detected in apple leaves collected from commercial and non-productive orchards and from backyard trees during the 3 years (1970-1972) are shown in Table 2. With two exceptions, the 1972 analyses results followed the same general pattern as was evident in 1970 and 1971. The two exceptions to the 3-year trend of similar chemical levels within the apple foliage occurred at locations 1000 and 2000 feet south. Levels of lead and arsenic within the foliage of apple trees in the commercially productive orchard increased greatly compared to 1971. As the ratio of lead to arsenic in these samples changed from approximately 30: 1 in 1971 to about 4: 1 in 1972, it appeared that the trees had been sprayed with the insecticide lead arsenate (lead: arsenic ratio of 3: 1). This was later confirmed in correspondence with the orchard operator. Further evidence of the lead arsenate application at this location was apparent from a comparison of the lead and arsenic levels for the two samples collected at the 1000-foot south location (Table 2). One sample was taken from a healthy productive tree in the sprayed portion of the orchard whereas the other was

tree, an unsprayed [illegible] ... approximately 20 feet away. The levels of lead and arsenic in the foliage of the unsprayed tree were much lower, and corresponded with the levels detected in 1970 and 1971. The lead:arsenic ratio for the unsprayed tree also was near the previously 1970 and 1971 ratio of 3.1.

<u>Vegetable Analyses Results</u>

As a result of the elevated levels of lead that were detected in leaf lettuce collected in the vegetable-growing area 1600 feet north of Tonolli in 1971, an in-depth lettuce sampling survey was conducted in 1972. The results of the four collection dates are shown in Table 3. Safe levels of lead below the Health Protection Branch's limit of 2 ppm in vegetables were detected in all samples which were analysed on an "as consumed, fresh weight basis".

TABLE 1

1972 Levels of Lead and Arsenic
in Grass and Top Inch of Soil
near E.S.B., Mississauga

Location	Grass		Top Inch of Soil	
	Lead (ppm)	Arsenic (ppm)	Lead (ppm)	Arsenic (ppm)
5 feet East of ESB fence	180	2.3	2700	34.0
400 feet East of ESB fence	63	1.2	530	9

TABLE 2

Levels of Lead and Arsenic in Apple Leaves
Mississauga Area
1970-1971-1972

Distance & Direction from Tomken & Dixie Roads	Type of Orchard	Lead (parts per million)			Arsenic (parts per million)		
		1970	1971	1972	1970	1971	1972
[illegible] feet W	non productive old orchard	265	21[illegible]	[illegible]	<[illegible]	[illegible]	[illegible]
[illegible] feet	non productive old orchard	[illegible]	41[illegible]	[illegible]	<[illegible]	[illegible]	[illegible]
[illegible] feet [illegible]	productive orchard	-	234	[illegible]	[illegible]	[illegible]	[illegible]
1000 feet [illegible]	productive orchard	1[illegible]	1[illegible]	[illegible]30	[illegible]	[illegible]	[illegible]
	non productive orchard		-	1[illegible]			
[illegible] feet [illegible]	same orchard as 1000 feet [illegible]	87	91	400	<[illegible]	[illegible]	[illegible]
[illegible] feet [illegible]	backyard apple tree	4[illegible]	3[illegible]	96	<[illegible]	1.[illegible]	[illegible]

TABLE 3

LEVELS OF LEAD IN LEAF LETTUCE COLLECTED

1600 FEET NORTH OF THE TONOLLI PLANT, MISSISSAUGA

1972

Date of Collection	Lead Content - ppm (washed)	
	Dry Weight	Fresh Weight
June 14, 1972	6	0.5
July 18, 1972	13	1.5
August 1, 1972	10	1.0
September 21, 1972	10	1.9

[illegible] Soil and [illegible] August 30 and [illegible]

Description of Investigations

On August 30, 1973, the assessment survey for the degree and extent of lead contamination in the vicinity of Tonolli and ESB, Mississauga was continued, similar to the surveys conducted in 1970, 1971 and 1972. Additional sampling was conducted on November 9, 1973 to further differentiate the effects of emissions from the two sources.

Lead Analyses Results

The lead analyses for forage (grass) and the top inch of soil collected on the four radii during the period 1970 to 1973 are shown in Tables 1 and 2. The results of sampling which was conducted in the immediate vicinity of ESB during 1972 and 1973 are shown in Table 3. Table 4 contains the results of the November 9, 1973 additional sampling.

On the basis of the 1973 results, isopleths of excessive lead contamination of vegetation (150 ppm in not washed foliage and 75 ppm in washed foliage) and of surface soil (600 ppm) have been drawn (Figures 1, 2 and 3). Shown also on these maps are the respective isopleths of extreme lead contamination (1000 ppm lead in vegetation and 10,000 ppm lead in soil). The locations of these extreme lead contamination isopleths on each map show that the Tonolli plant is the major source of lead emissions in the area.

Approximately 150 residential properties lie within the area affected by excessive lead levels in vegetation. Approximately 10 of these properties are located in an area of extreme lead contamination of both soil and vegetation. It should be noted that, although the Tonolli plant is the major source of lead emissions in the area, the emissions from the ESB plant appear to have an effect on a greater number of residential properties. This is due to the proximity of the residential development located to the south and east of ESB. Land usage in the vicinity of the Tonolli plant consists primarily of commercial and undeveloped sites with only a few isolated residential dwellings.

TABLE 1

Levels of Lead in Forage (grass)
Collected in the Vicinity of the Tonolli and CSB Plants,
Mississauga 1970 - 1973.

Station Number	Distance and Direction	Description of Sampling Area	Total Lead Content Parts Per Million (Washed,Dry Weight Basis)			
			1970	1971	1972	1973
0	Tonolli Road	industrial lawn	227	1840	2100	1800
1 N	1000'N	farm fence row	27	11	28	17
2 N	2000'N	undeveloped land	5	13	24	9
3 N	3000'N	edge of ravine	4	7	--	--
1 W	1000'W	railway right of way	12	140	640	170
2 W	2000'W	undeveloped land	3	17	20	14
3 W	3000'W	residential area	12	15	8	12
1 E	1000'E	industrial property	19	31	140	135
2 E	2000'E	residential area	7	51	96	48
3 E	3000'E	residential area	13	23	23	79
1 S	1000'S	undeveloped land	8	59	72	57
2 S	2000'S	residential-orchard	4	11	12	74
3 S	3000'S	residential area	2	4	14	36

TABLE 2

Levels of Lead in the Top Inch of Soil
Collected in the Vicinity of the Tonolli and ESB Plants,
Mississauga, 1970 - 1973

Station Number	Distance and Direction	Description of Sampling Area	Total Lead Content (parts per million dry weight)			
			1970	1971	1972	1973
0	Tonolli Road	industrial lawn	5200	3050	11000	11250
1 N	1000'N	farm fence row	612	35	130	100
2 N	2000'N	undeveloped land	140	107	160	155
3 N	3000'N	edge of ravine	59	35	-	-
1 W	1000'W	railway right of way	450	550	3800	1500
2 W	2000'W	undeveloped land	194	194	250	225
3 W	3000'W	residential area	283	40	180	220
1 E	1000'E	industrial property	340	196	1100	710
2 E	2000'E	residential area	185	58	400	510
3 E	3000'E	residential area	216	180	35	200
1 S	1000'S	undeveloped land	136	55	170	65
2 S	2000'S	residential-orchard	53	107	110	105
3 S	3000'S	residential area	81	77	80	130

[illegible]

LEVELS OF LEAD IN GRASS AND THE TOP INCH OF SOIL
COLLECTED IN THE VICINITY OF THE ESB PLANT
[illegible] 1972-1973

Sampling Station	Distance and Direction from Source	Description of Area	Lead Content ppm - Dry Weight			
			Washed Grass		Top Inch of Soil	
			1972	1973	1972	1973
ESB - 1	50 feet NE	ESB property	160	204	2700	3425
ESB - 2	450 feet NE	ESB property	49	92	530	475
ESB - 3	100 feet ESE	elevated highway median	-	-	-	690
ESB - 4	400 feet S	residential area	-	117	-	540

TABLE 4

LEVELS OF LEAD IN VEGETATION, FORAGE AND SURFACE SOIL
COLLECTED IN THE VICINITY OF THE TONOLLI AND ESB PLANTS,
MISSISSAUGA, NOVEMBER 9, 1973.

Sampling Station	Description of Sample Area	Lead Content ppm - Dry Weight		
		Washed Vegetation	Washed Forage	Surface Soil
1	2430 Dixie Rd. - residential property bordering Tonolli plant	269	787	16,800
2	NE edge of Tonolli property	-	-	10,200
3	S side of Tonolli Rd. - 600'S	-	80	478
4	Vacant property - 800'SW of Tonolli	-	23	233
5	Vacant property - 1200'SW of Tonolli	-	36	320
6	Vacant property - 1800'WSW of Tonolli	-	82	163
7	2420 Dixie Rd. - residential property between Tonolli and ESB	979, 384	205	978
8	Watson - Orchard Dr. - residential area W of Dixie Rd.	58	-	193
9	2107 Cortland Dr. - residential area W of Dixie Rd.	55	-	163
10	1371 Safeway Cres. - residential area E of Dixie Rd.	85	-	153
11	2363 Denise Rd. residential area E of Dixie Rd. (400'SE of ESB)	458	-	1560
12	vacant area off Caterpillar Rd.	-	47	348
13	industrial park - 1500'NW of Tonolli	-	15	88

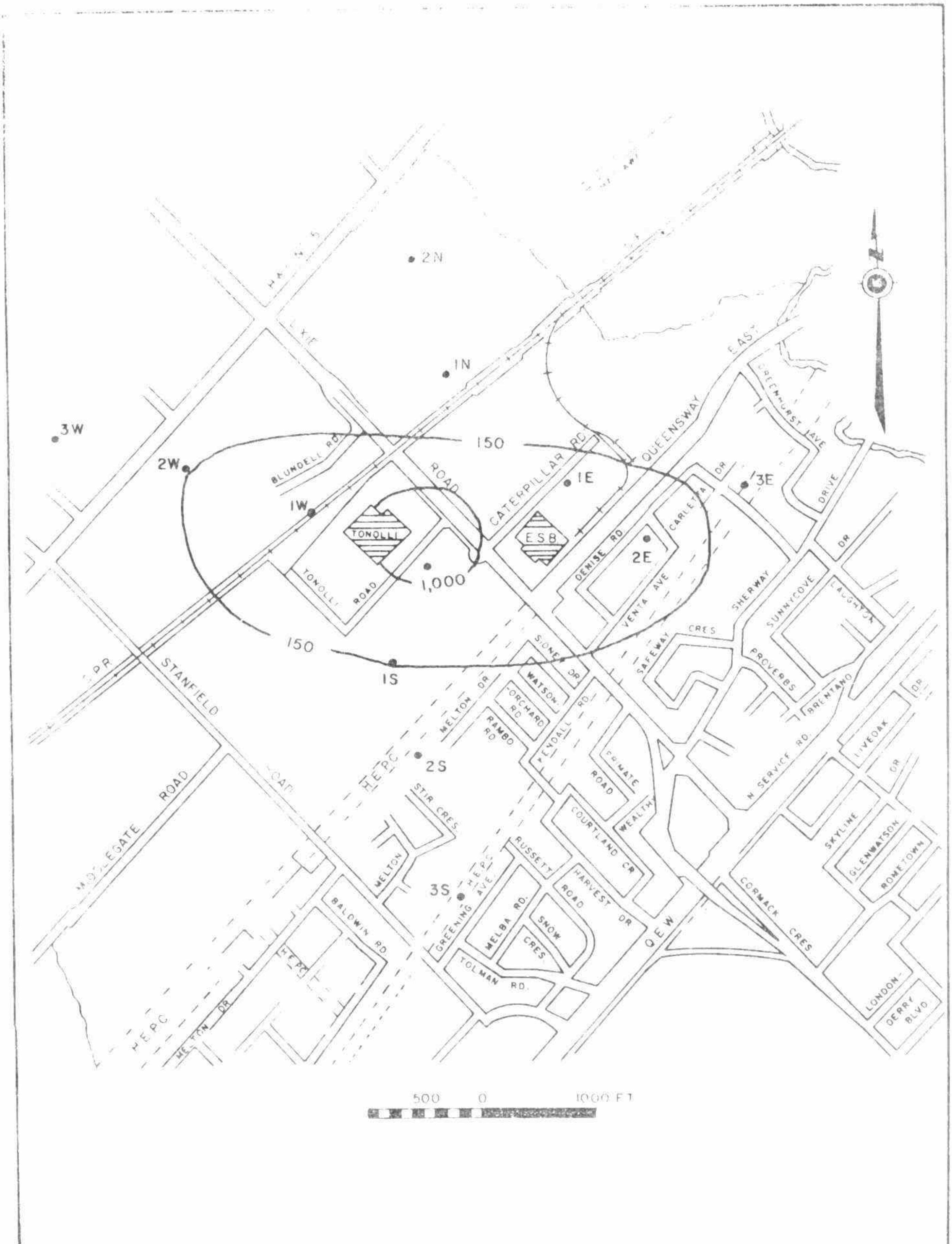
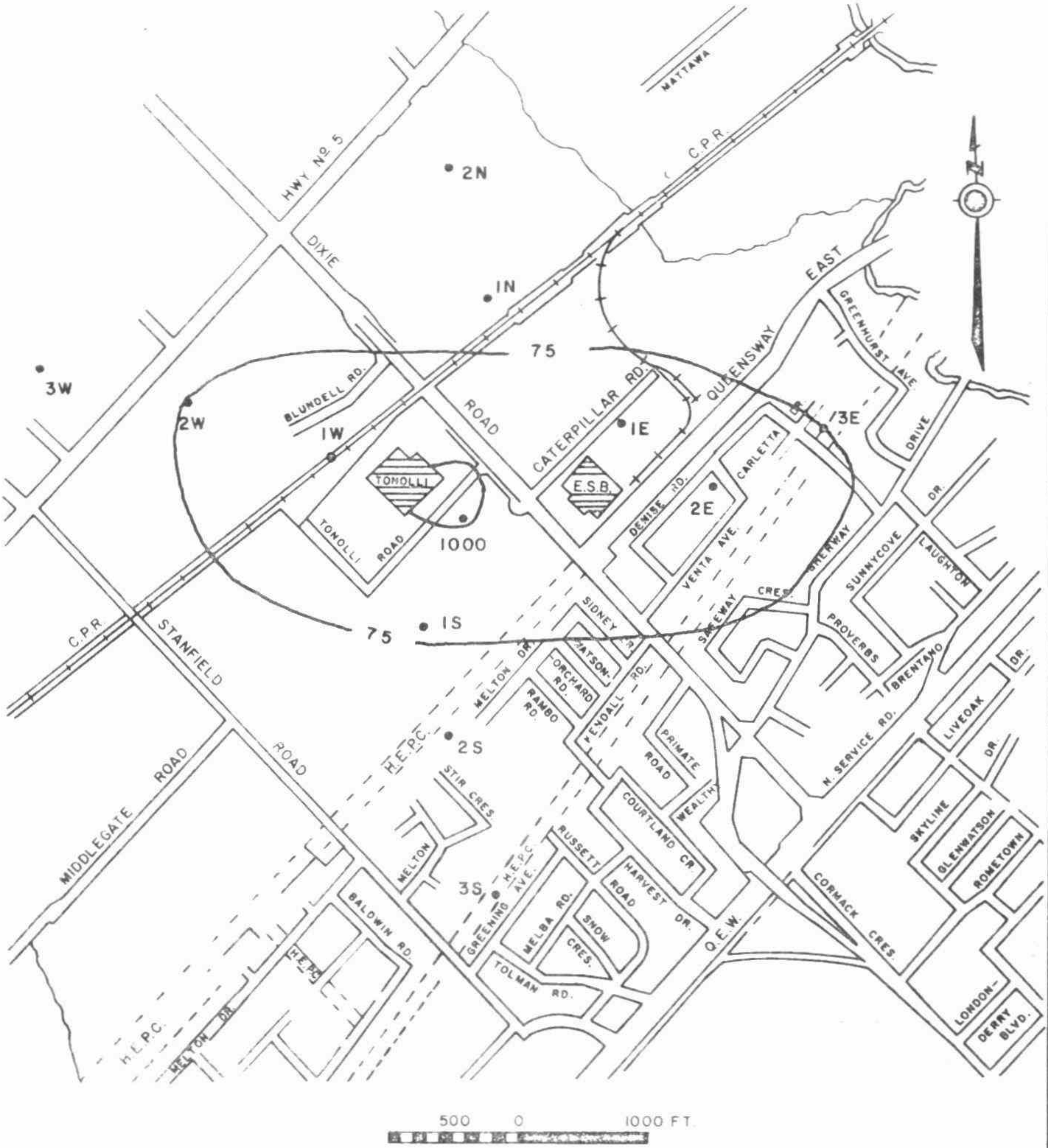


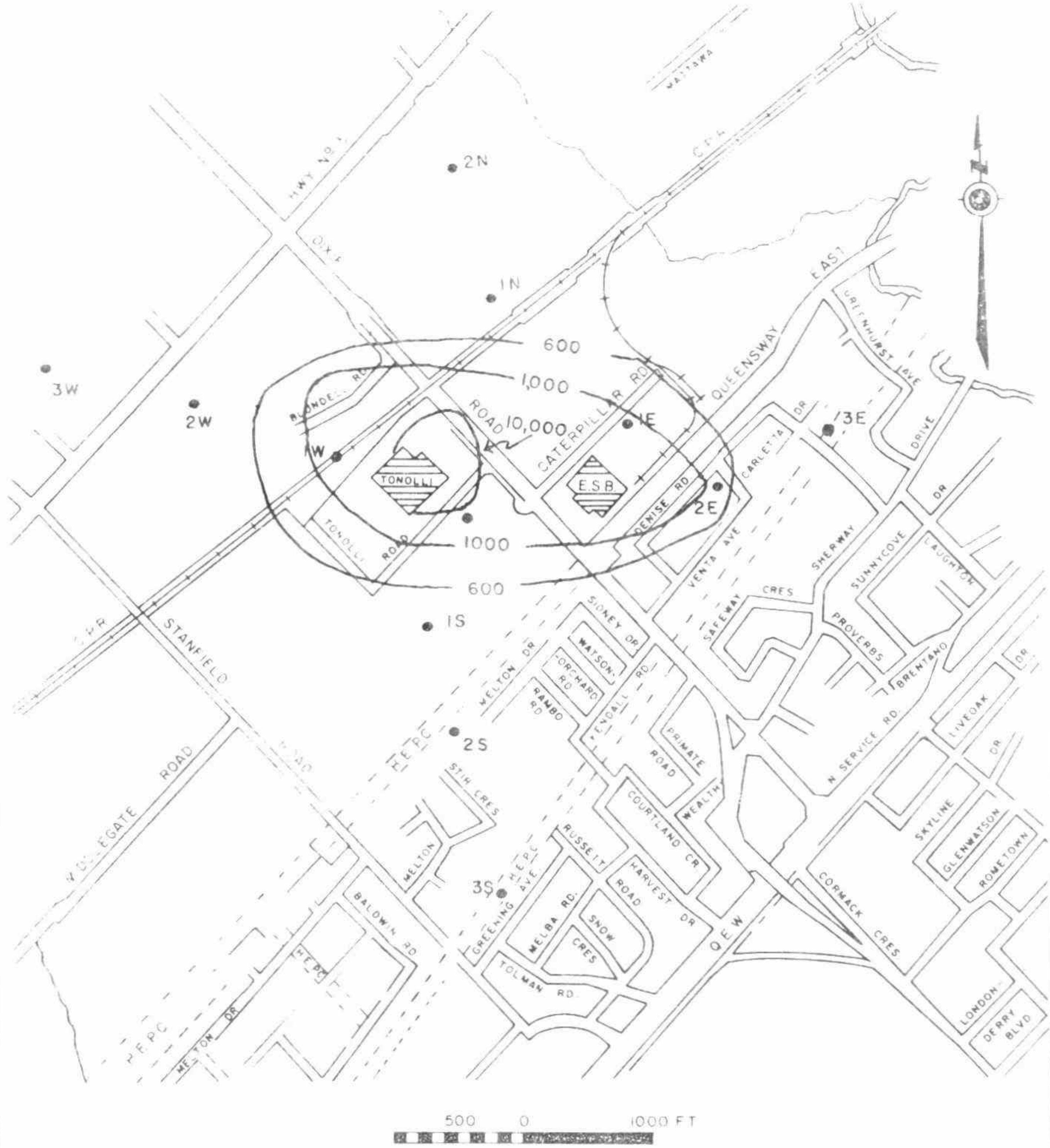
FIG. 1 - ISOPLETHS OF LEAD CONTAMINATION (IN ppm) OF UNWASHED



6.4.4.5.

DRG. No 5125

FIG. 2 - ISOPLETHS OF LEAD CONTAMINATION (IN ppm) OF WASHED VEGETATION, MISSISSAUGA - 1973.



6.4.4.5

DRG. No 5126

FIG. 3 - ISOPLETHS OF LEAD CONTAMINATION (IN ppm) OF SURFACE

6.4.7 Tonolli and Electric Storage Battery of Canada Analysis

a) Abatement Activities - Tonolli Company of Canada

The Tonolli Company have made improvements to their secondary lead recovery operations in the past two years, including modifications to the baghouse to improve control of fumes from the smelting and refining furnaces, new controls on the battery crusher/separator and significant improvements in housekeeping and separation of vehicular traffic.

Used batteries are still broken by bulldozer in a walled-off area of the yard and battery scrap transported to an enclosed building by front end loader. In the past problems have occurred during the removal and handling of collected lead dust from the baghouse but now an enclosure has been erected and more care is being taken.

It is anticipated that further actions will be required of the Company to reduce emissions from materials, handling and scrap processing operations to meet criteria (see Sections 6.4.5 c,g,d and e).

b) Abatement Activities - ESB of Canada Limited

Since the Company embarked on a major abatement program under Ministry supervision in late 1972, many significant improvements have been made to control emissions of lead from the battery manufacturing operations.

[illegible] installation of new control equipment will continue to September, 1974.

Based on experience with similar battery plants it is anticipated that these abatement measures will prove effective in reducing emissions to meet desirable ambient acceptable air levels.

c) Suspended Lead in the Vicinity of Tonolli and ESB

The air quality samplers close to the Tonolli plant have recorded extremely high levels of suspended lead with both the proposed and existing air quality criteria being exceeded a large part of the time. Correlations indicate that the highest readings occur with winds from the Tonolli plant with a small elevation with winds from ESB and Dixie Road.

The air sampler near the ESB plant has recorded much lower levels of lead, particularly in recent months but the air quality criteria are still being exceeded. Wind correlations with lead levels now implicate Tonolli as the main source.

The lead particle size distribution near Tonolli shows that more of the particles are in the large size range with a mass median equivalent aerodynamic diameter as great as 50 µm occurring with winds from the direction of the Tonolli plant. Particles of this size would suggest fugitive emissions as the main source of high lead levels at Tonolli.

d) Lead in Dustfall

Lead in dustfall is elevated above the suggested guideline of 0.3 tons/mile^2/30 days and is particularly high close to Tonolli. Elevated levels are mainly in the industrial area and levels in the residential area to the south of the plant are more typical of an urban area.

e) Lead in Soil

During the period 1970-1973 samples of soil taken in the area continued to show excessive levels of lead in an elliptical area 1000 feet east-west and 600 feet north-south surrounding the Tonolli and ESB plants. The most severe area of soil contamination is adjacent to the Tonolli plant with levels in excess of 10,000 ppm found within 300 feet of the plant. Over 40 residences are situated in an area where the soil is contaminated above the guideline of 600 ppm.

f) Lead Contamination of Vegetation

During the years 1970 - 1973, surveys of the lead contamination of vegetation in the area showed continuing excessive contamination in an elliptical area of 2000 feet wide in the east-west direction and 800 feet in the north-south direction surrounding the Tonolli and ESB plants. The most severe area of vegetation contamination is adjacent to the Tonolli plant with levels in excess of 1000 ppm found within 500 feet of the plant.

[illegible]

[illegible]

Summary

The combined effect of operations of the Tonolli Company of Canada and the Electric Storage Battery Company has been to cause lead contamination of air, dustfall, soil and vegetation in the vicinity of the plants.

The data collected by the Ministry of the Environment indicate that emissions from the Tonolli Company are by far the major contributor to this contamination.

Tonolli has taken and is continuing to take measures to abate emissions but the monitoring data fail to show any significant improvement in contamination of soil and vegetation since 1970 and air quality data show that suspended lead levels with winds from the direction of the Tonolli plant have not decreased since late 1973. The high suspended lead levels are associated with large particles probably from fugitive sources.

The assessment of the degree of contamination due to ESB, is complicated due to the overriding influence of Tonolli. It is possible to say that between 1970 and 1973 there was no large change in the degree of vegetation contamination near ESB but air quality monitoring data do indicate a recent improvement in lead levels measured at the samplers under conditions that winds are predominantly from the direction of ESB.

The operations of Tonolli apparently require further control to limit fugitive dust emissions from the property.

[illegible] control area

A map of the control area showing the location of the sampling stations is given in Figure 6.5.1-1. The control area was chosen to include expressways and other traffic arteries which are similarly in the areas of the lead smelters. The results of the measurements of lead in suspended particulate matter and dustfall are given in Tables 6.5.1-I and 6.5.1-II. It may be noted that Ontario's criteria for lead are not exceeded in the control area. The area is about one mile away from Canada Metal. The maximum concentrations of lead in suspended particulate matter are up to 4 ug/m^3, which indicates the effects of the traffic on the expressways as well as possibly the transport from as far away as Canada Metal.

TABLE 6.5.1-I

CONTROL AREA
LEAD LEVELS IN SUSPENDED PARTICULATE MATTER

Station No.	Location Name	Location Description	Period Sampled	No. of Days Sampled	Geom. Mean $\mu g/m^3$	Maximum Conc. $\mu g/m^3$	No. of Days Conc. >5 $\mu g/m^3$	% of Days Conc. >5 $\mu g/m^3$	No. of Days Conc. >15 $\mu g/m^3$	% of Days Conc. >15 $\mu g/m^3$
51082	138 Hamilton Ave.	Toronto Works Dept.	22/1/74 to 30/4/74	67	1.18	3	0	0	0	0
51083	701 Gerrard St. East	Eastdale Voc. School	22/1/74 to 31/5/74	93	0.87	4	0	0	0	0
51084	65 Saulter St.	Commercial Bldg.	27/1/74 to 30/4/74	50	1.02	4	0	0	0	0

TABLE 6.5.1-II

CONTROL AREA

TOTAL LEAD IN DUSTFALL

1 9 7 4 TONS PER SQUARE MILE PER MONTH

[illegible]	LOCATION	JAN.	FEB.	MAR.	APR.	MAY	JUNE	JULY	AUG.	SEPT.	OCT.	NOV.	DEC.	[illegible]
032	138 Hamilton St.		.07	.09	.08	.16								
53	701 Gerrard St.		.04	Invalid	.03	.05								
34	65 Saulter St.		.05	.04	.04	.08								

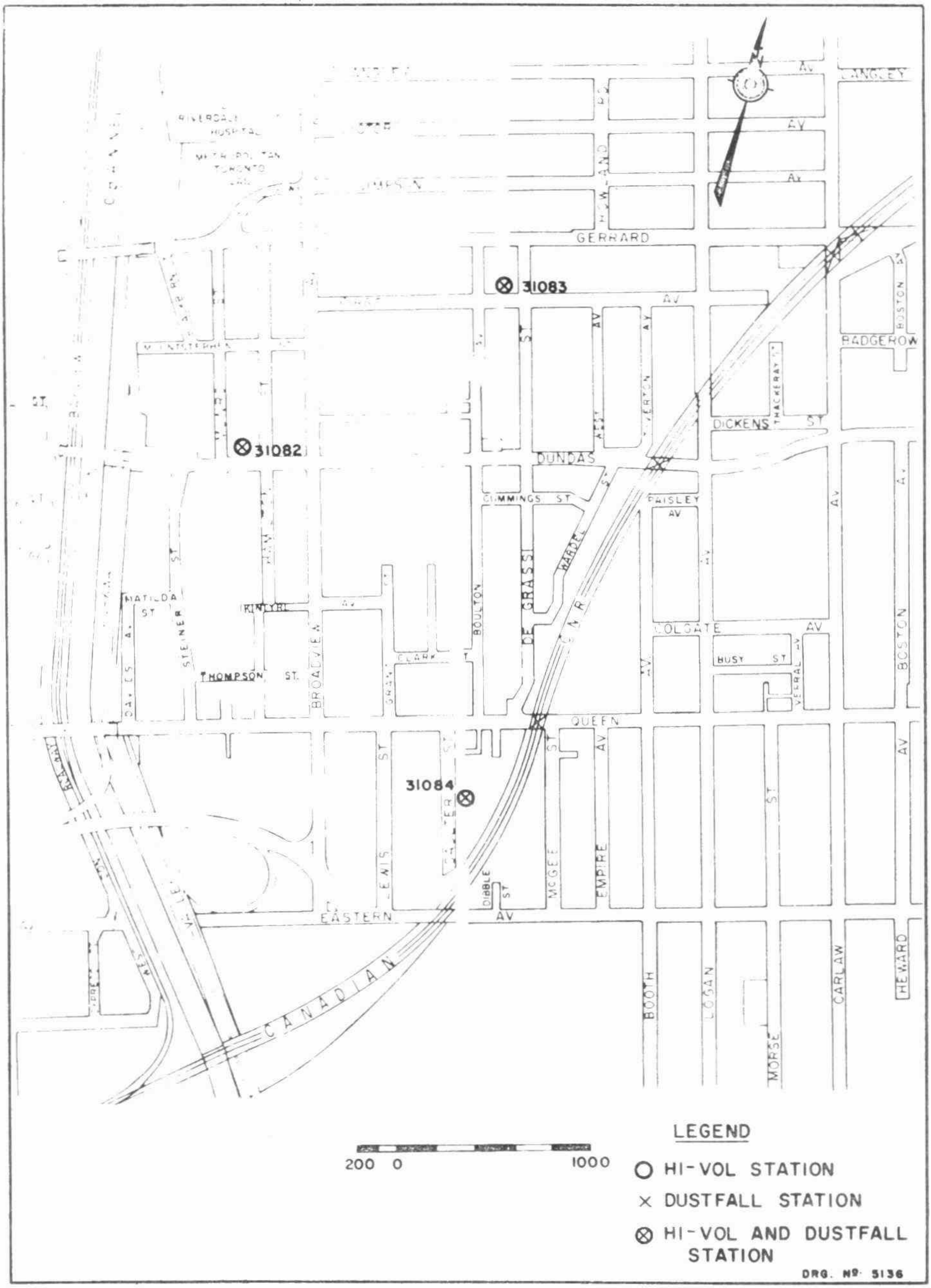


FIGURE 6.5.1-1 - LOCATION OF AIR MONITORING STATIONS IN THE CONTROL AREA

6.5.2 Summary of Lead in Soil and Vegetation in the Toronto Control Area

The key conclusions of phytotoxicology assessment surveys conducted in the Toronto Control Area are:

1) Soil samples were collected at 47 locations within the Control Area on December 11, 1973. Three zones possessing excessive levels of lead in soil were determined. Two zones adjoined streets with heavy automobile traffic and one zone adjoined the Don Incinerator. The remainder of the Control Area possessed soil with lead levels normal for a downtown urban location.

2) Vegetation samples were collected at 24 locations within the Control Area on January 4 and 7, 1974. Two zones possessing excessive levels of lead in vegetation were determined; both adjoining road intersections with heavy automobile traffic. The remainder of the Control Area had lead contents in vegetation which were within normal limits for an urban area.

Descriptions of these surveys follow, which include sampling locations, analyses results and their interpretation.

6.5.2.1 Phytotoxicology Assessment Survey for Lead in Soil - December 11, 1973

This survey was conducted to provide background levels of lead in soil in a residential area not influenced by industrial sources. The boundaries of the Control Area are The Don River on the west, Gerrard Street on the north, and the CNR tracks on the east and south.

Soil at depths of 0-2" and 2-4" was collected at 47 locations throughout the Control Area, and analysed for lead. The results of these analyses are shown in Table 1.

The attached map shows three pockets of excessive lead in soil found within the Control Area. Two of these pockets adjoin streets with heavy automobile traffic, and the other pocket adjoins the Don Incinerator. The remainder of the Control Area possesses soil with elevated lead levels which are normal for a downtown urban location.

TABLE 1 - LEAD LEVELS IN SOIL COLLECTED IN CONTROL AREA

Station No.	Soil Pb, PPM dry weight	
	0-2"	2-4"
1	213	275
2	308	288
3	910	760
4	435	413
5	80	25
6	48	30
7	500	435
8	575	313
9	668	238
10	1030	3180
11	650	618
12	445	425
13	763	600
14	700	375
15	488	460
16	80	30
17	18	28
18	595	775
19	1200	1210
20	720	715
21	1080	585
22	368	355
23	145	110
24	590	605
25	130	105
26	538	330
27	345	425
28	350	285
29	230	238
30	1200	1700
31	675	518
32	295	195

Station No.	0-2"	2-4"
33	378	655
34A	230	210
34B	415	233
35	283	275
36	270	283
37	883	805
38	975	680
39	1450	750
40	335	350
41	363	365
42	335	350
43	53	75
44	388	308
45	213	238
46	245	35
47A	80	43
47B	245	145
Average	480	458

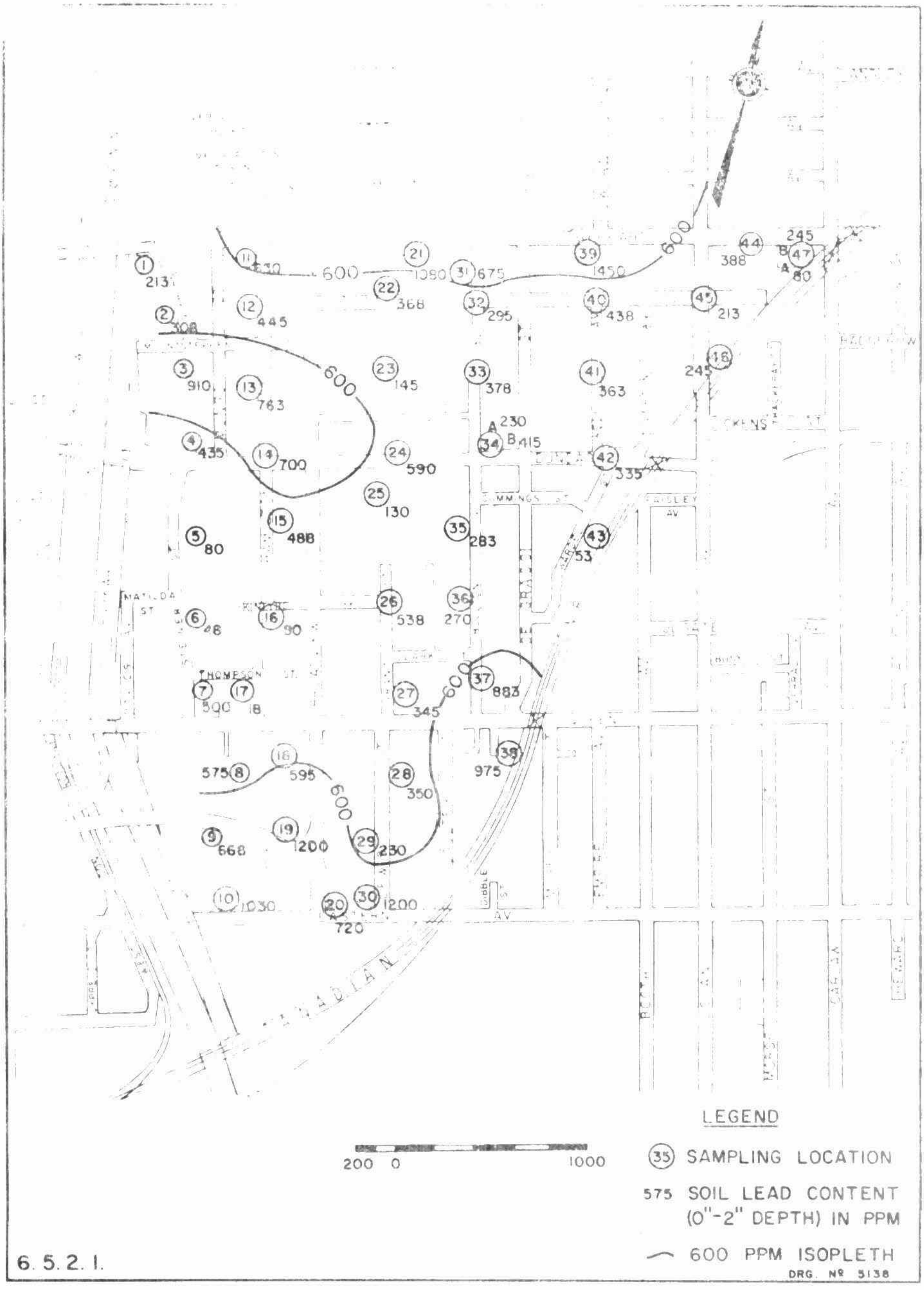


FIGURE 1 - ISOPLETHS OF LEAD CONTENT IN SURFACE SOIL IN THE CONTROL AREA -

6.5.1.2 Phytotoxicology Assessment Survey for Lead in Vegetation - January 4 and 7, 1974

Description of Investigation

This survey was conducted to provide background levels of lead in vegetation in the Control Area.

In the previous survey (December 11, 1973), 47 stations had been established in this area for the collection of soil samples. Using these locations as a sampling framework, evergreen foliage was collected at all stations where suitable species could be found (sampling locations are shown on the attached map). Vegetation samples were analysed in the washed and not washed states for contents of lead and several other metals.

The results of the chemical analyses for lead contents of the collected vegetation are shown in Table 1. Excessive levels of lead in washed, 1973 foliage were found at only four stations (1, 10, 19 and 20), all located in either the north-west or south-west corners of the area. The values for washed, 1973 foliage were used to draw isopleths (75 ppm) of lead content of vegetation as shown on the attached map. Excessive foliar lead levels reflected heavy vehicular traffic on nearby main arteries.

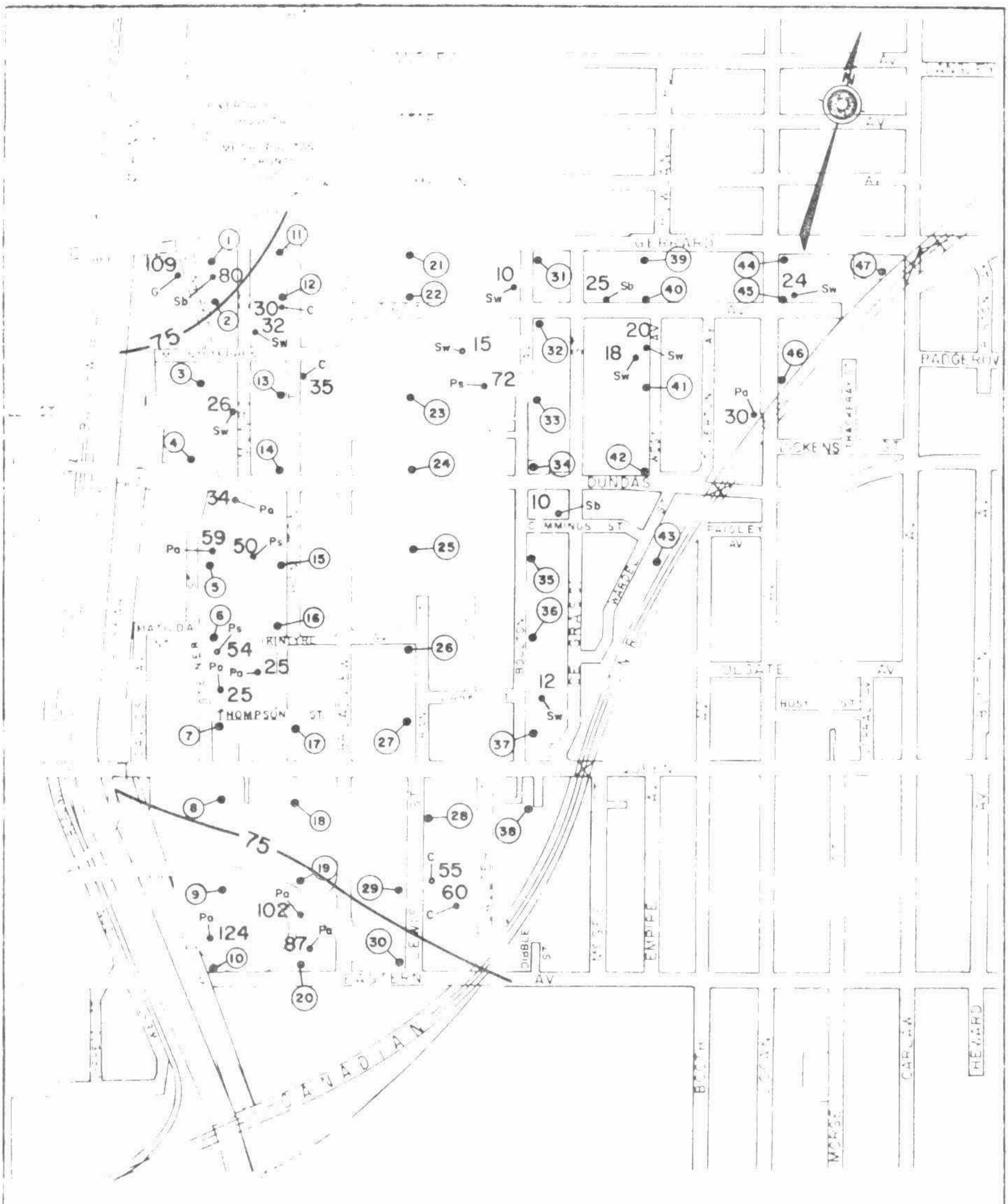
Results of chemical analyses for foliar content of other heavy metals indicated that Cd, Cr, Fe, V, and Zn were within normal limits for vegetation in an urban area.

TABLE 1

LEAD CONTENT OF FOLIAGE IN CONTROL AREA

Station No.	Species	Lead Content (ppm, dry weight) 1973 Foliage NW	W
1	Blue Spruce	155	80
	Grass	123	109
2	White Spruce	55	32
3	White Spruce	55	26
4	Austrian Pine	78	34
5	Austrian Pine	83	59
6	Scotch Pine	90	54
7	Austrian Pine	45	25
10	Austrian Pine	253	124
12	White Cedar*	54	30
13	White Cedar*	56	35
15	Scotch Pine	75	50
16	Austrian Pine	30	25
19	Austrian Pine	112	102
20	Austrian Pine	122	87
22	White Spruce	22	15
29	White Cedar*	100	60
	White Cedar*	90	55
31	White Spruce	20	10
33	Scotch Pine	75	72
35	Blue Spruce	15	10
37	White Spruce	32	12
40	Blue Spruce	58	25
41	White Spruce	20	20
	White Spruce	32	18
45	White Spruce	80	24
46	Austrian Pine	44	30
Level Considered Excessive		150	75

NW - not washed; W - washed; * - samples of white cedar were a composite of 1972 and 1973 foliage.



LEGEND

① STATION LOCATION

Sb ACTUAL COLLECTION LOCATION

12 LEAD CONTENT OF WASHED, 1973 FOLIAGE (PPM, DRY WEIGHT)

ISOPLETH OF LEAD CONTENT IN VEGETATION

6.5.2.2.

200 0 1000

SPECIES KEY

C CEDAR

G GRASS

Pa AUSTRIAN PINE

Ps SCOTCH PINE

Sb BLUE SPRUCE

Sw WHITE SPRUCE

DRG. Nº 5137

FIGURE I - VEGETATION SAMPLING LOCATIONS IN THE CONTROL AREA - JAN. 4, 7, 1974

7.1 Preliminary Data Compilation

7.1.1 Definitions of Areas

For the purpose of this report, areas are defined as follows. The definitions are somewhat arbitrary: the criterion was to include most of the people tested for blood lead in an area, within a distance not too far from the suspected lead source. The control area was defined before sampling.

Toronto Refiners and Smelters Limited Area - is bounded by Queen Street on the north, Spadina Avenue on the east, C.N.R. tracks on the south and Niagara Street on the west.

Prestolite Battery Company Limited Area - is bounded by St.Clair Avenue on the north, Shaw Street (and points north) on the east, Bloor Street (or slightly beyond) on the south and C.N.R. tracks (or slightly beyond) on the west.

The Canada Metal Company Limited Area - is bounded by Gerrard Street (or slightly beyond) on the north, Woodfield Road (or slightly beyond) on the east, Lakeshore Boulevard on the South, C.N.R. tracks on the west.

The Control Area - is bounded by Victor Avenue (or slightly beyond) and points west, on the north, C.N.R. tracks on the east and south, and the Don River on the west.

7.1.2
Tabulation Methodology and Criteria

Figures 7.2-2, 7.2-4, 7.2-6 and 7.2-8 each have a grid marked on them related to U.T.M. (Universal Transverse Mercator) co-ordinates. Each square is 250 metres square. Tabulations of people tested for blood lead were organized according to the squares in which they reside. There is some error possible close to the boundaries of squares as to which square a person was assigned to for these tabulations. This is because assignment was made by computer according to the co-ordinates of the residence, not by address, and there was error of up to 10 metres possible in the co-ordinates.

The meaning of "slightly beyond" in the Area Definitions is that some squares overlapped the stated boundary and the exact location of the people tested from those squares was not ascertained as to whether they were strictly within the boundary.

There were also people tested from squares completely beyond the boundaries defined, whose blood lead results are not included in the tabulations to follow, because of the great distance from a lead plant.

7.1.3
Description of the Data Base

Health data regarding blood lead tests has been supplied to us on computer magnetic tape by the City of Toronto. The first tape, produced March 5, 1974 included blood lead test results for all clinics held in Toronto from May, 1973 up to and including February 7, 1974. The second tape, received July 1974, added all

[illegible] 1974 [illegible] tape. It also included extensive editing and re-organization of the data on the first tape. No tapes received from the City contained the name or the address of any individual. All persons and addresses are represented on the tape by code numbers and the code is kept by persons under the authority of the Medical Officer of Health. A summary follows of dates of clinics for which data is on each tape.

Summary of Dates of Blood Lead Clinics for Which Data is on Magnetic Tape

	Dates on First Tape	Additional Dates on Second Tape
Toronto Refiners and Smelters Area	Many dates in May, June, Sept., 1973	
Prestolite Battery Co.	Dec. 12, 1973; Jan. 10, 16, 24, 31/74; Feb. 7/74	Feb. 14/74; Mar. 27/74 Apr. 24/74; May 21/74
Canada Metal Co.Ltd., Area	Oct. 15/73; Dec. 3, 10/73; Jan. 14/74	Mar. 7, 14/74; Apr. 22, 30/74
Control Area	Jan. 22, 28/74	Apr. 29/74.

Those tested at a clinic were not necessarily resident in that area. All clinics mentioned on the first tape are also on the second tape.

The variables on the first tape used in preliminary analyses were, for each blood test, the age, sex, distance of residence from a lead plant and blood lead level of the person tested.

The second tape includes the variables on the first, with some missing data supplied and editing done. In particular, several distances previously missing have been calculated by assigning map co-ordinates to the residence of every person tested and to the lead plants under study. All the blood tests for people tested more than once have been collected into one tape file for each such person. The tape files for each person tested from the same residence have been placed consecutively before a file containing information for that residence, such as map co-ordinates, measured and calculated distances from the nearest lead plant and average lead level of all persons tested from that residence. All work involving confidential coding of name, addresses and personal information was carried out by staff at Toronto City Hall.

Some preliminary analyses were done on data from the first tape, using only test dates where follow-up tests were not done. They are not being reported because of the amount of missing data and unedited data on that tape.

Thus, for the present report, it is most suitable to work with data from the second tape.

7.1.4
Sample Bias

The people tested for the first time at all clinics came voluntarily from among all those who might have come. Therefore, they do not comprise a random sample representative of the populations in the control area or in the areas of the lead plants under investigations. The above remarks do not entirely apply to Toronto Refiners and Smelters area, where door-to-door sampling was done.

[illegible]

necessarily representative of the total population of the control area. The same remark applies to all areas, and to all variables of interest in addition to age, name, sex, distance of residence from plant, blood lead level, etc.

It is thus important to realize that the samples tested are self selected samples and thus possibly biased. It seems reasonable to assume that the probability of a person's coming for testing (the first time) would be directly proportional to that person's (or that person's parents') concern about possible past lead exposure. Two hypotheses can be advanced about the type of selection present:

1. This concern should be directly proportional to proximity to a lead plant.

   The results of this would be that a greater proportion of people living "close" to a lead source than of those living "far" would come for testing. Preliminary data tabulations have indicated that this is indeed generally true.

2. This concern should be greater for those with possible increased lead exposure as a result of their life-style and habits, including occupation type and location, cooking utensils, playing habits and location.

   One result of this would be that a greater proportion of children compared with adults would come for testing, both among those living "close" and "far" from lead sources, or among all those in the control area.

The interaction of these two types of selection results in samples being heavily weighted by children living close to a lead plant.

An additional source of bias overall is that (in some clinics) the population sampled were school-age children, their parents and pre-school brothers and

sisters. This is really a two-stage sampling procedure, in that adults and pre-school children were "selected" only from families with school-age children. Because of this hypothesis, two can not be tested. Of course, some other persons came to clinics as a result of word-of-mouth information and had blood samples taken.

The result of the selective biases evident in the samples tested is that associations found in the samples between high lead levels and age, or distance from a lead plant, may not hold for the whole population in each area.

In order to give an idea of this sample bias, the four Figures 7.2-2, 7.2-4, 7.2-6 and 7.2-8, one of each area, are presented.

On each square is marked the estimated percentage of residences within the square from which people came to have blood lead tests. This was calculated by counting the total number of residences in each square from a detailed City map and by computing the number of residences in each square from which people were tested. Thus, it is possible to estimate the proportion of persons in any area who actually attended a clinic compared with those who were theoretically able to attend but did not do so.

It can be seen from the first three figures that the proportions tested generally decrease with distance from a lead source.

From 1971 census data (Statistics Canada Catalogue 95-721(CT-21A), Series A) it was found that there are on the average about two males plus two females per

[illegible] in those homes where persons were tested, about one male plus one female per residence were tested in the Prestolite Battery Company, Canada Metal Company and Control Areas, but about two males plus two females in the Toronto Refiners and Smelters Company Limited area, where door-to-door sampling was done.

Whereas each area contains slightly more males than females according to census data, samples tested contained slightly more females than males in each area except Toronto Refiners (where door-to-door canvassing was employed). This slight bias toward female inclusion is likely due to mothers being more available than fathers to bring children for testing.

This is evident from Table 1 showing sample breakdown by age for the Prestolite Battery Company, Canada Metal Company and Control Area combined (Toronto Refiners and Smelters Limited area was omitted because of the door-to-door sampling).

This Table also shows that the samples consist primarily of people aged 14 and under (school children). In fact, 78.8% of all males and 68.1% of all females tested in those three areas were in that age range. A smaller but significant number fall into the 25-64 age group, namely 13.6% of all males, 22.7% of all females in the three areas combined, with females (mothers) outnumbering males (fathers), as pointed out earlier.

This distribution is, of course, quite different from the actual population distribution in each area, found from census data.

? 1.5 Preliminary Treatment of Data

Results

A "good" blood lead test is defined as one for which two capillary tubes of blood were analyzed and gave readings of blood lead differing by less than 17 mcg/100 ml whole blood. The result of that test is the average of the two readings

In tabulating results, only people with at least one "good" blood test were included. (This applies to preceding maps and tables also.)

If a person had more than one "good" test, the average of his/her "good" tests was used. If, however the first test was high enough to warrant treatment, such treatment may affect the second reading. Such an effect would cause the number of blood lead values over 40 mcgs. to be slightly underestimated. Tables 2, 3, 4 and 5 show the number of blood lead levels 40 mcg/100 ml whole blood, or more, in each area, tabulated by age and sex. The percentage of all tests in each subgroup which were 40 mcg or more is also given.

Generally speaking, a percentage of 2 5 - 3.0 or more of levels above 40 mcg is considered "abnormal" or excessive. Percentages based on only one test 40+ however, are somewhat suspect because of possible analytic erross. Furthermore, percentages based on small numbers tested have large standard deviations.

Overall percentages for an area should be age adjusted for differences in the age make-up between areas and this is now being done.

No tests of significance have yet been made because corrections for sample bias have not yet been carried out.

Age and Sex Related Characteristics of Persons Having Elevated Blood Lead Levels

Canada Metal Company Area -

Males:

It can be seen from Table 2. that every age group except the group 20-24 have an excessive percentage of elevated blood lead levels. These percentages are based on a large enough population tested to yield a small standard deviation.

Females:

The percentages of elevated lead levels are excessive in the 45 to 64 year age group and in the 0-9 age group with the group 10-14 years old being borderline. As with the males, the population is large enough to yield a small standard deviation.

Toronto Refiners and Smelters Limited Area -

Males:

The numbers tested, as seen in Table 3, are small when separated into age groups. There is some suggestion of excessive percentages of high blood leads in all age groups except those 15 to 24 years old.

Females:

The numbers tested are small and there is an indication of an increased percentage of elevated blood lead levels only in 0-9 year olds.

Prestolite Company Area -

Males:

Table 4. shows that children 0 to [illegible] years old and adults aged

25 to 64 years old show an increased percentage of elevated blood lead level. As in the Canada Metal area, the excess of elevated levels in male adults should be noted.

Females:

Only in the 0 to 4 year old age group is there an excessive percentage of elevated lead levels.

Control Area -

Males:

No blood lead levels above 40 mcg/100 ml were found in children under 14 years old. Too few people over 14 were tested to allow any conclusions to be drawn.

Females:

The same remarks apply as in the male population.

SUMMARY -

Great caution must be exercised in considering the data presented for the reasons given but, if it is assumed that the sample of children tested from each area are indeed representative of all of the children in that area, there is a tendency for there to be an increased percentage of children having elevated blood lead levels in the areas close to the lead plants compared with the control area.

The reason for this tendency must await analysis of the epidemiological data which has been collected and is now being analyzed.

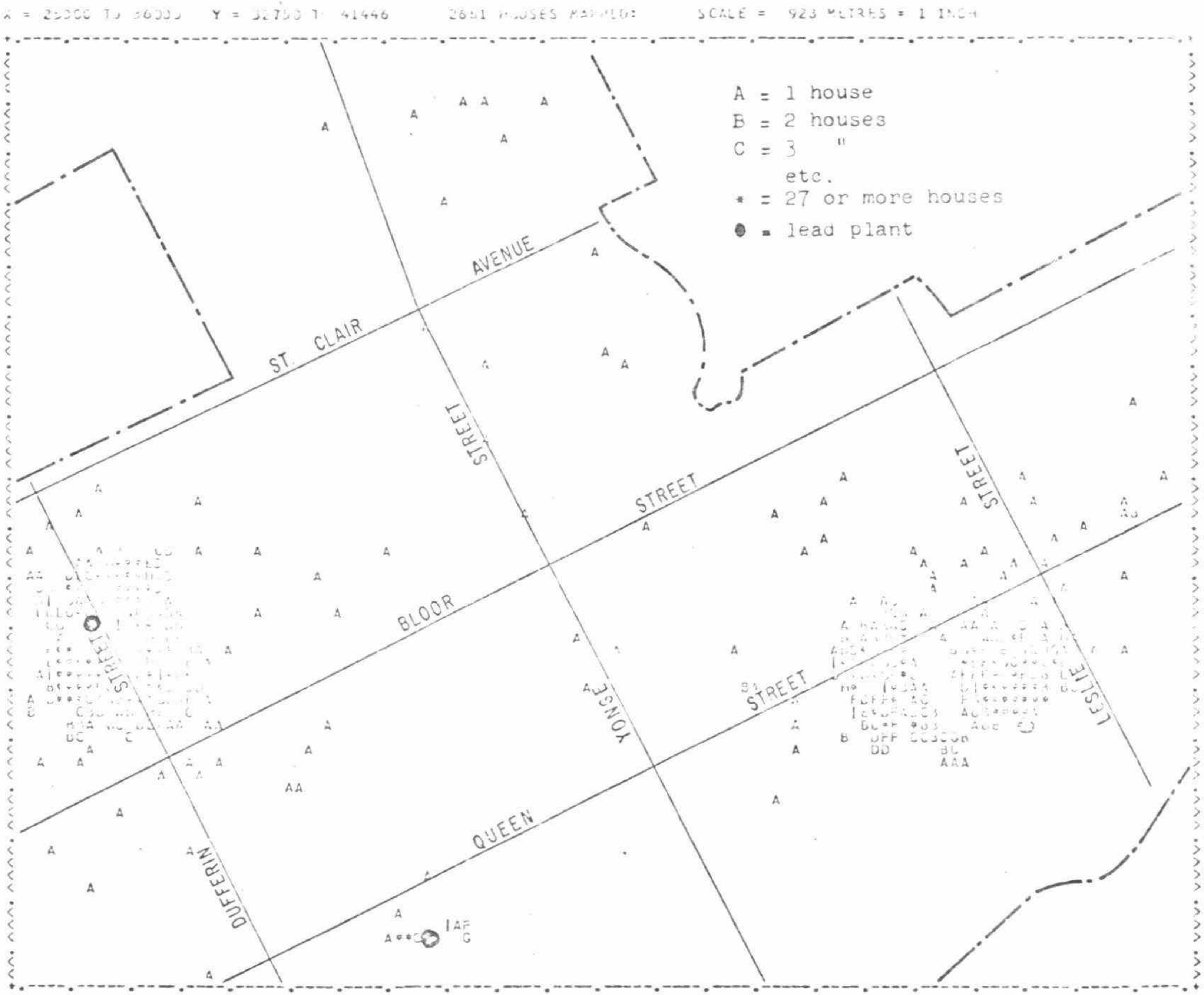


Figure 7.1.0 [redacted] City of Toronto [redacted] Lead [redacted] pling [redacted] ocat [redacted]

TABLE 1.

AGE DISTRIBUTION OF PEOPLE TESTED BY SEX,

in the PRESTOLITE, CANADA METAL AND CONTROL AREAS COMBINED

AGE GROUPS

MALES	0 - 4	5 - 9	10 - 14	15 - 19	20 - 24	25 - 44	45 - 64	65+	All [illegible]
Number Tested	266	1068	713	115	48	223	130	34	[illegible]
Percent of Total	10.2	41.1	27.5	4.4	1.8	8.6	5.0	1.3	100

FEMALES									
Number Tested	264	1045	762	132	104	473	219	44	[illegible]
Percent of Total	8.7	34.3	25.0	4.3	3.4	15.5	7.2	1.4	[illegible]

7.2 Sampling Program Description

7.2.1 Canada Metal Company Limited

Sampling in the vicinity of the Canada Metal Company was done in community centres (school-based) relying on the voluntary participation of residents in the area. Information and consent forms were sent home covering the school children, and the adults were invited to come along, and especially to bring their pre-school age children with them.

The micro-sampling technique was used, collecting samples by finger-prick in micro-tubes. These samples were sent to the Environmental Science Associates Laboratories in Burlington, Massachusetts, U.S.A. for testing by the anodic stripping voltametry method (AVS).

Centres were held at Bruce School and St. Josephs School in October and December 1973, and January 1974. Approximately 1,600 persons have been initially screened in this area.

A team of physicians whose members variously worked in the Toronto Department of Public Health, the Ontario Ministry of Health, and the Toronto Hospital for Sick Children decided that a blood level of less than 30 micrograms per 100 ml of whole blood need not be tested further. If the blood lead level was in the 30-39 microgram ranges, the individual would be retested at approximately 3 month intervals until two consecutive tests were registered below 30 micrograms. Persons were referred for special follow-up examination including clinical tests as required. Almost all of these persons reported to a special centre established for the purpose at the

Hospital for Sick Children. A few choose to consult their personal physicians.

The follow-up screening and examination of those with elevated levels continues.

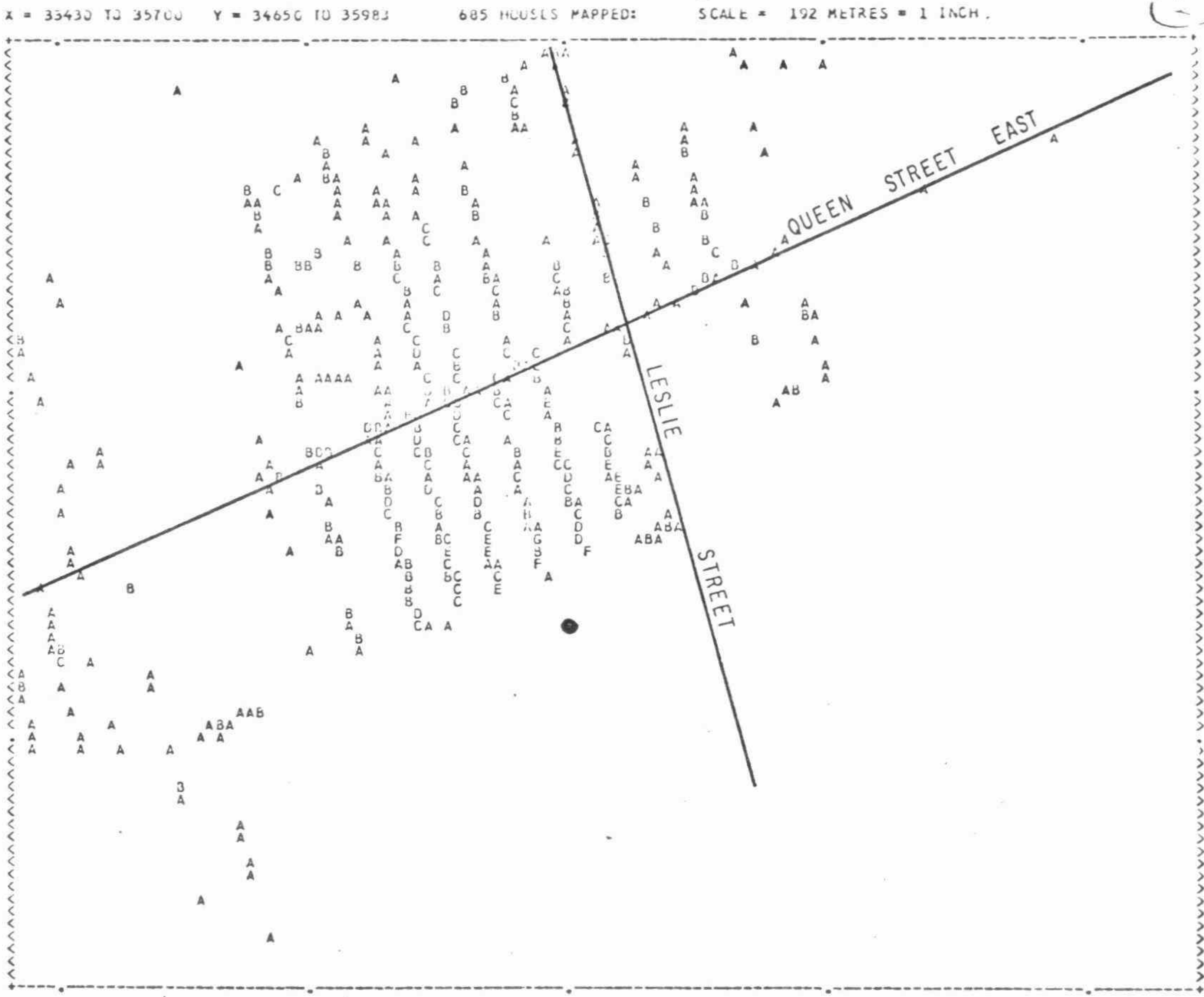


Fig. 7.1-1 Canada Metal Area - Blood Lead Sampling Locations

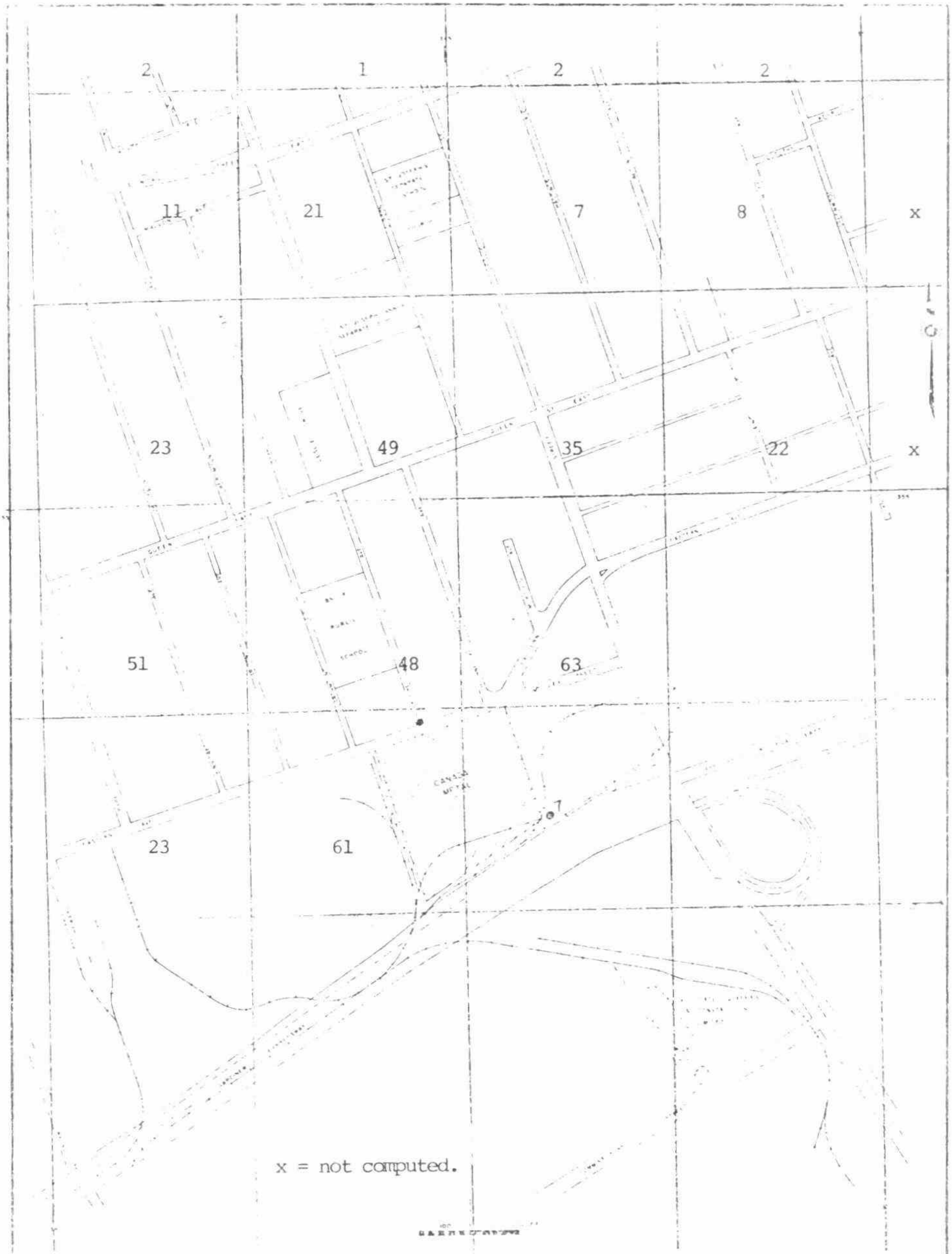


FIG. 7.2-2

Percentage of Residences "tested" near Canada Metal
(as of May 21, 1974)

TABLE 2.

CANADA METAL LIMITED AREA

NUMBER AND PERCENTAGE OF ELEVATED BLOOD LEAD LEVELS.

BY AGE AND SEX.

AGE GROUPS

MALES	0 - 4	5 - 9	10-14	15-19	20-24	25-44	45-64	65+	ALL AGES
Number Tested	69	223	212	59	25	66	63	25	742
Number 40+	14	13	6	3	0	5	5	3	49
Percentage 40+	20.3	5.8	2.8	5.1	0	7.6	7.9	12.0	6.6

FEMALES									
Number Tested	79	226	214	62	43	140	95	32	891
Number 40+	5	7	5	0	1	2	3	0	23
Percentage 40+	6.3	3.1	2.3	0	2.3	1.4	3.2	0	2.6

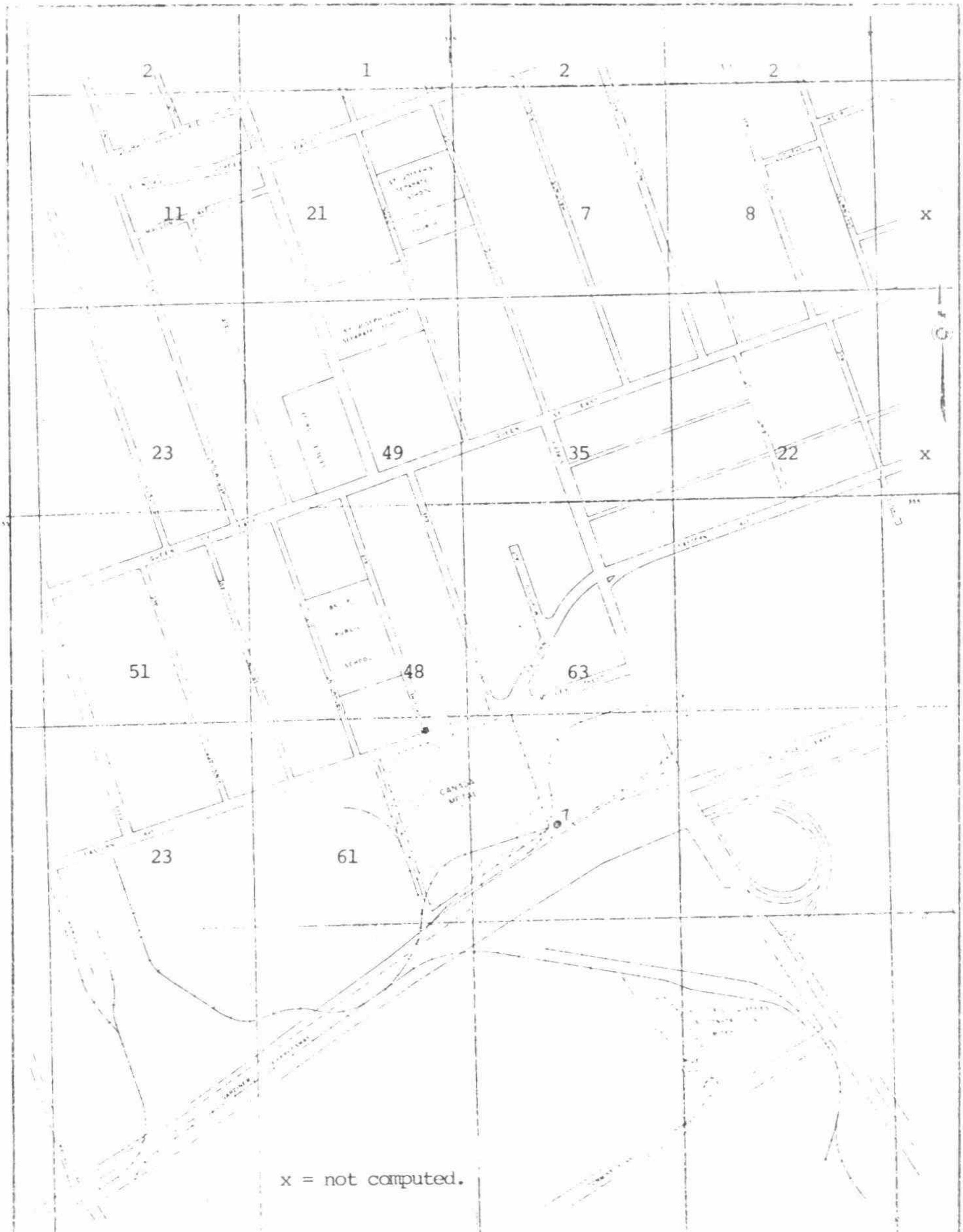


FIG. 7.2-2

Percentage of Residences "tested" near Canada Metal
(as of May 21, 1974)

TABLE 2.

CANADA METAL LIMITED AREA

NUMBER AND PERCENTAGE OF [illegible]

By [illegible]

AGE GROUPS

MALES	0 - 4	5 - 9	10-14	15-19	20-24	25-44	45-64	65+	ALL AGES
Number Tested	69	223	212	59	25	66	63	25	742
Number 40+	14	13	6	3	0	5	5	3	49
Percentage 40+	20.3	5.8	2.8	5.1	0	7.6	7.9	12.0	6.6

FEMALES									
Number Tested	79	226	214	62	43	140	95	32	891
Number 40+	5	7	5	0	1	2	3	0	23
Percentage 40+	6.3	3.1	2.3	0	2.3	1.4	3.2	0	2.6

7.2.2 Toronto Refiners and Smelters Limited

Members of several families living in close proximity to the Toronto Refiners and Smelters Limited had blood samples taken by a physician of the Ministry of Health, a Toronto Department of Public Health Physician collected blood specimens from residents living on the south side of Niagara Street abutting the plant and consenting to the procedure in September 1972. These specimens consisted of 10 cc venous blood and were tested in the Laboratories of the Ministry of Health for lead.

In February/March 1973, this type of sampling was extended to both sides of Niagara Street between Bathurst and Tecumseh.

In May/June 1973, the survey was further extended to take in several blocks of residences in the vicinity of the plant bounded by Niagara, Wellington and Bathurst Streets, and also including Draper Street. Most of the sampling was done in the home. Approximately 175 gave venous samples of blood which were sent for testing as previously outlined by the Ministry of Health. Samples of this venous blood were also collected in micro-tubes and sent to the ESA Laboratories in Burlington, Massachusetts, U.S.A. for testing by the anodic stripping voltametry (ASV) technique. An additional 100 persons approximately contributed finger-prick samples of blood for ASV testing.

Since that time, follow-up testing has continued at regular intervals involving persons whose blood lead levels were elevated on the initial screening.

X = 28450 TO 29500   Y = 33000 TO 33499   63 HOUSES MAPPED: SCALE = 64 METRES = 1 INCH

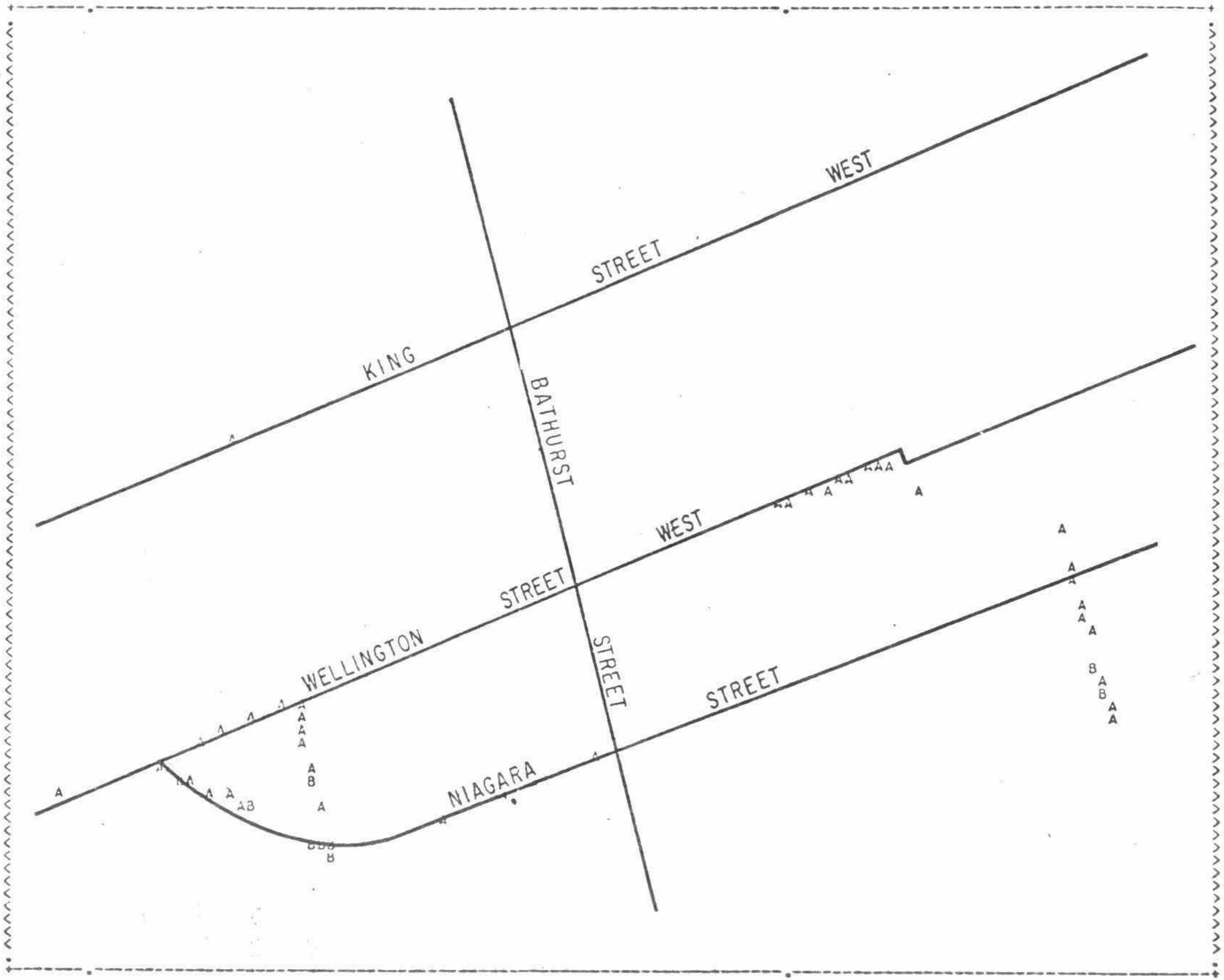


Fig. 7.1-2   Toronto Refiners Area - Blood Lead Sampling Locations

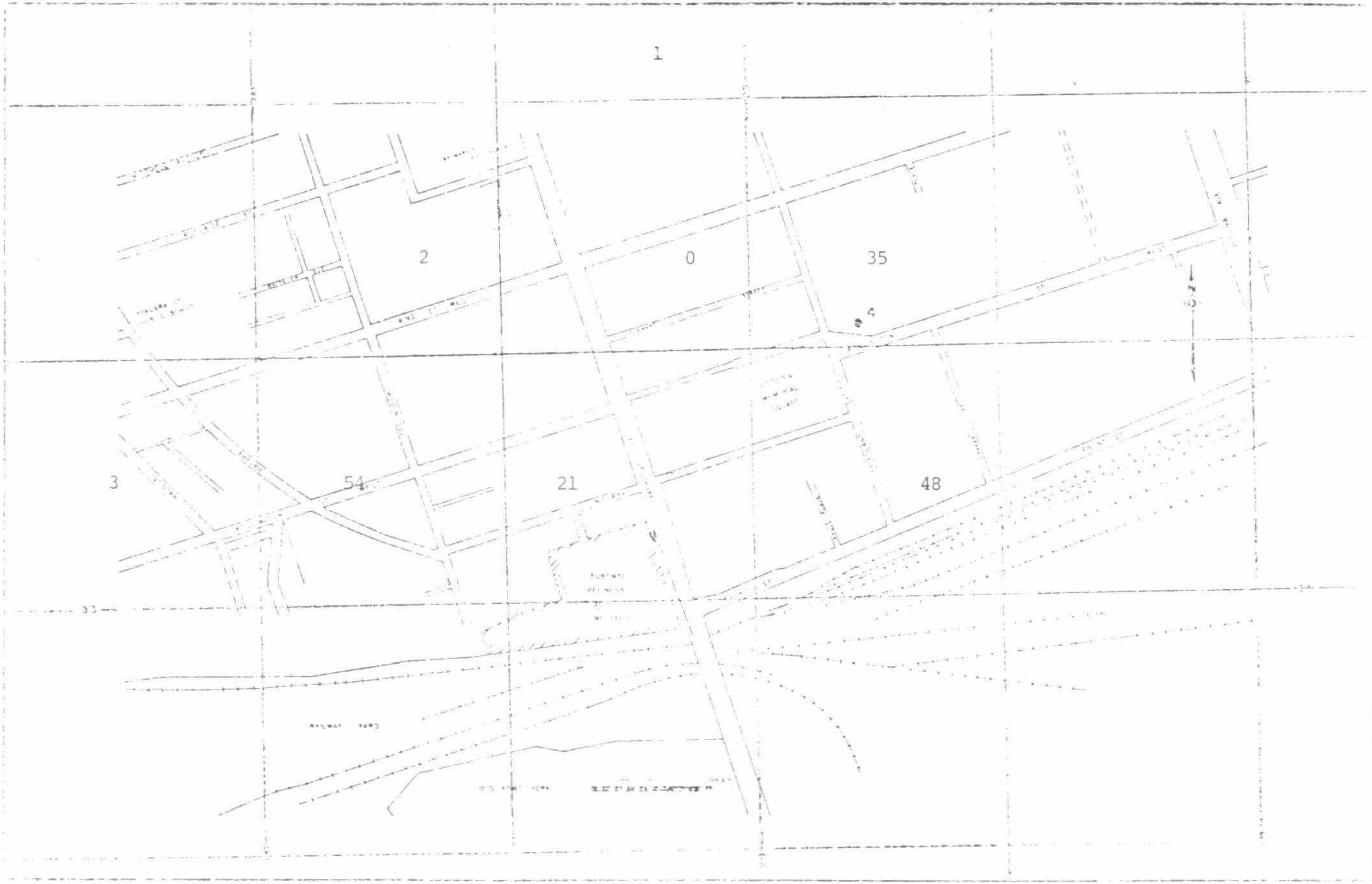


FIG. 7.2-4 Percentage of Residences "Tested" NEAR TORONTO REFINERS AND SMELTERS
(as of May 21, 1974)

TABLE 3.

TORONTO REFINERS AND SMELTERS LTD. AREA

NUMBER AND PERCENTAGE OF 'ELEVATED' BLOOD LEAD LEVELS.

by Age and Sex

AGE GROUPS

MALES	0 - 4	5 - 9	10-14	15-19	20-24	25-44	45-64	65+	All Ages
Number Tested	10	19	15	15	14	33	22	6	134
Number 40+	1	5	1	0	0	1	4	1	13
Percentage 40+	10.0	26.3	6.7	0	0	3.0	18.2	16.7	9.7
FEMALES									
Number Tested	13	13	15	8	11	35	19	4	118
Number 40+	1	2	0	0	0	0	0	0	3
Percentage 40+	7.7	15.4	0	0	0	0	0	0	2.5

7.2.3 Prestolite Company (Division of Eltra Limited)

Sampling in the vicinity of the Prestolite Company (Division of Eltra Limited) followed exactly the pattern established in the Canada Metal Company area.

It was conducted in school-based community centres in December 1973, and January and February 1974. Micro-samples of finger-prick blood were sent to the ESA Laboratories for analysis by the ASV method.

Approximately 3,000 persons were screened and follow-up testing and clinical examination of those with elevated levels is continuing.

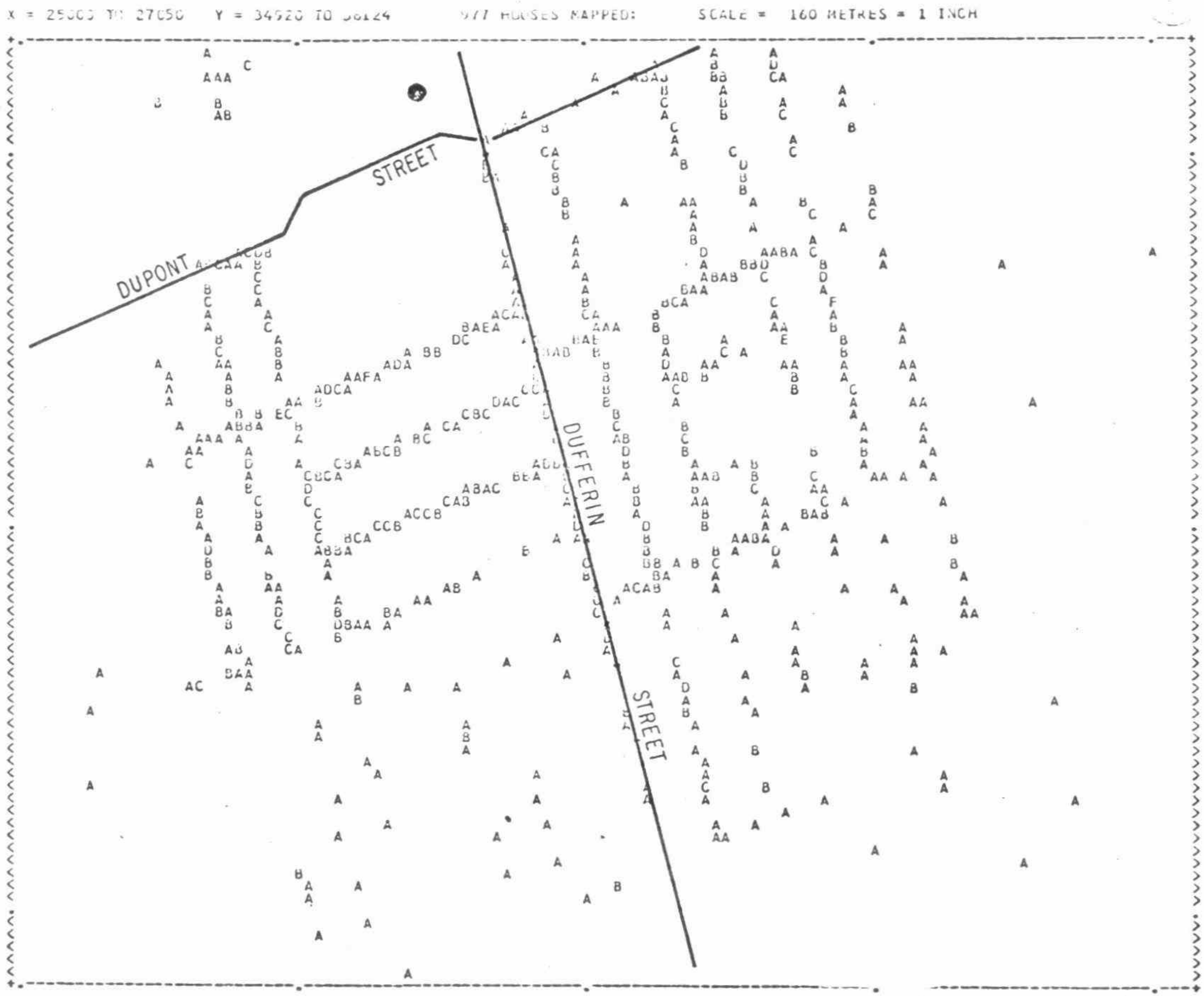


Figure 7.1-3 Prestolite Area - Blood Lead Sampling Locations

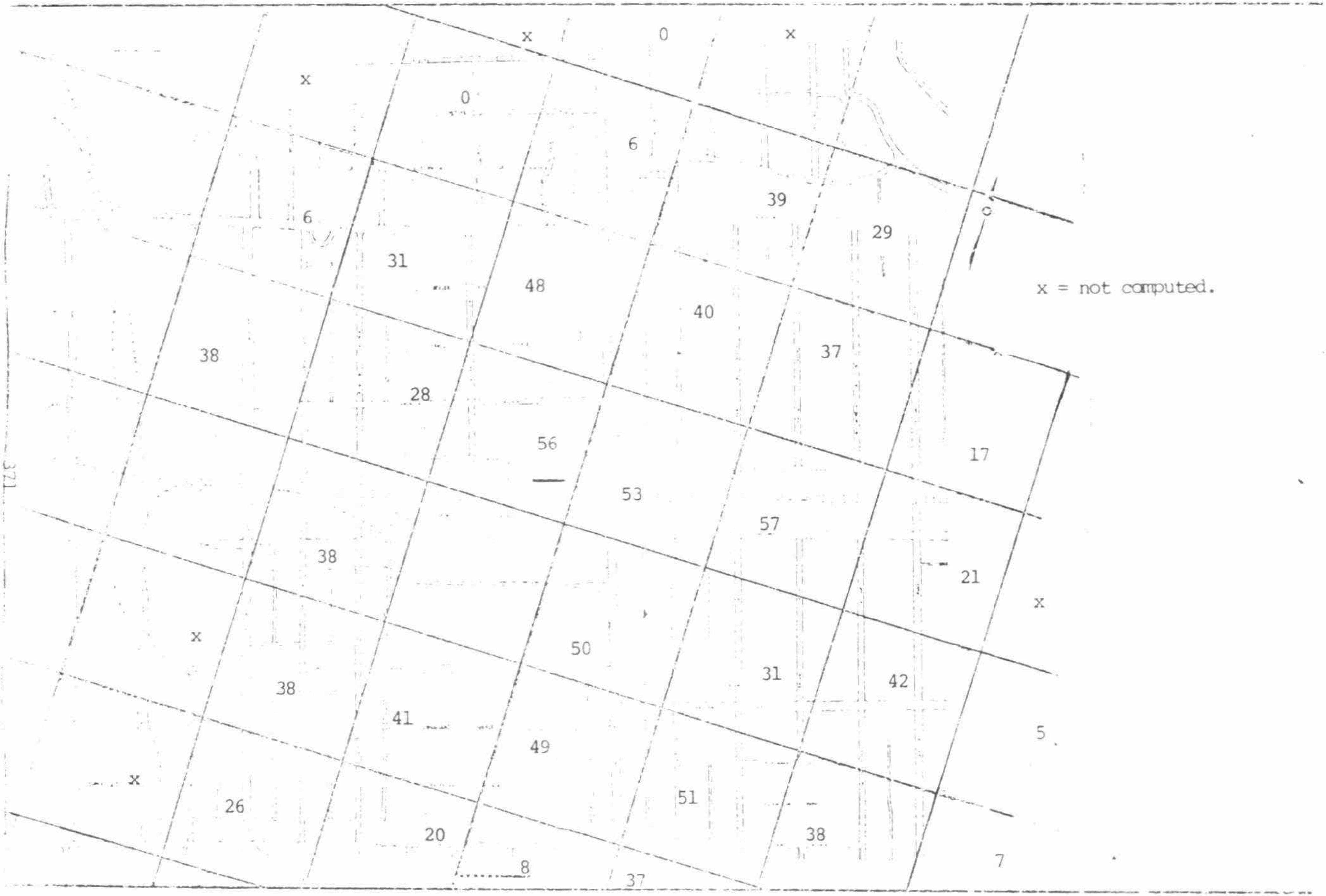


Figure 7.2- 6 Percentage of Residences "Tested" Near Prestolite (as of May 21, 1974)

TABLE 4.

PRESTOLITE COMPANY AREA

NUMBER AND PERCENTAGE OF [illegible] BLOOD LEAD LEVELS

by Age and Sex

[illegible]

	0 - 4	5 - 9	10-14	15-19	20-24	25-44	45-64	65+	All Ages
MALES									
Number Tested	160	617	376	49	22	144	59	8	1,435
Number 40+	6	17	6	0	0	7	3	0	39
Percentage 40+	3.75	2.8	1.6	0	0	4.9	5.1	0	2.7
FEMALES									
Number Tested	154	598	409	58	51	309	107	11	1,697
Number 40+	6	6	4	0	0	1	0	0	17
Percentage 40+	3.9	1.0	1.0	0	0	0.3	0	0	1.0

7.2.4 Control Area

A Control Area generally representative of the three test areas but without the presence of a known source of industrial lead was selected in the part of the City of Toronto bounded by the Don Valley on the west, Gerrard Street on the north, and the CNR right-of-way on the east and south.

A school-based community survey was conducted in January 1974. Micro samples of finger-prick blood were sent to the ESA Laboratories for analysis by the AVS method.

Approximately 1,300 persons were screened and the few requiring follow-up are being attended to.

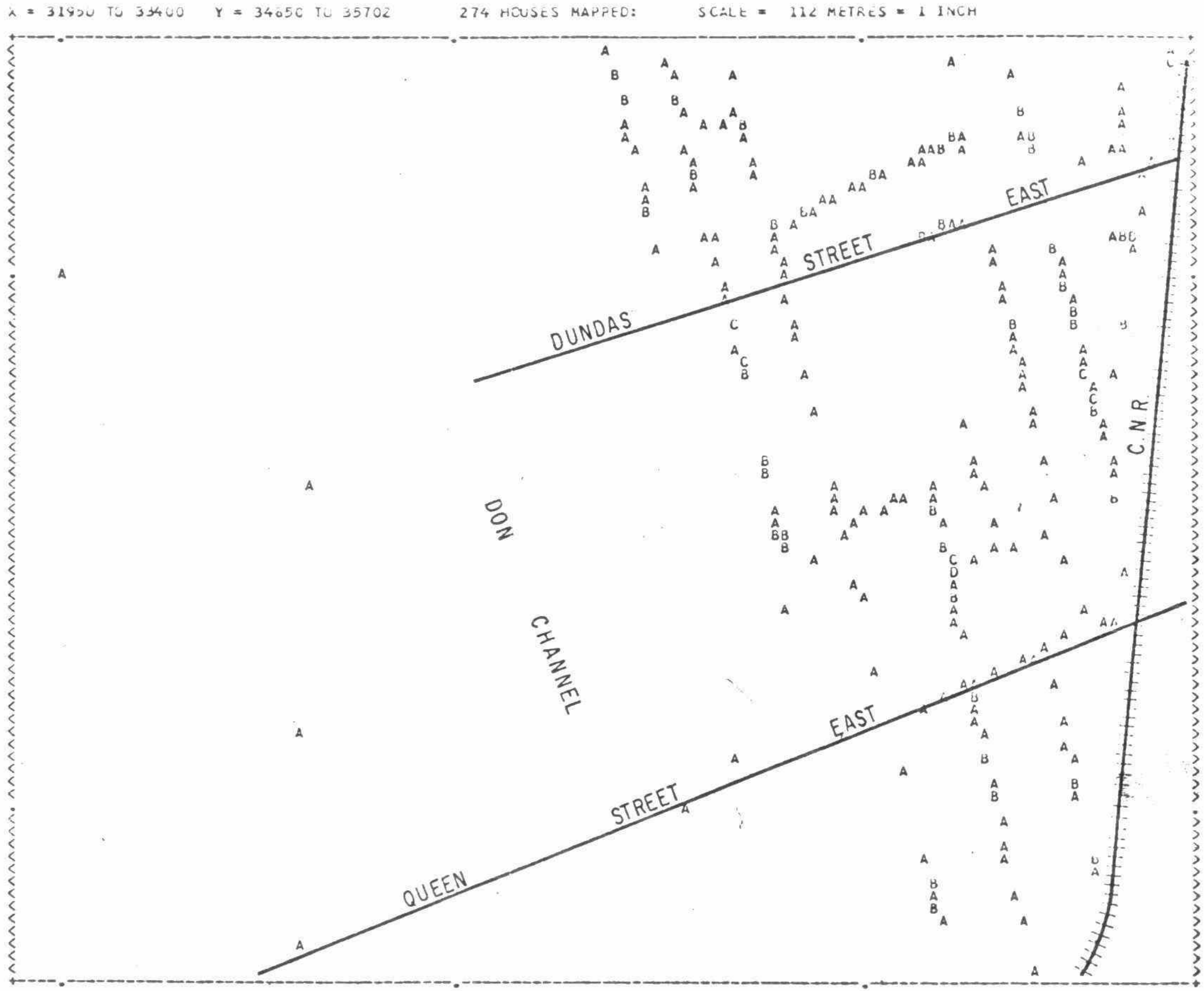
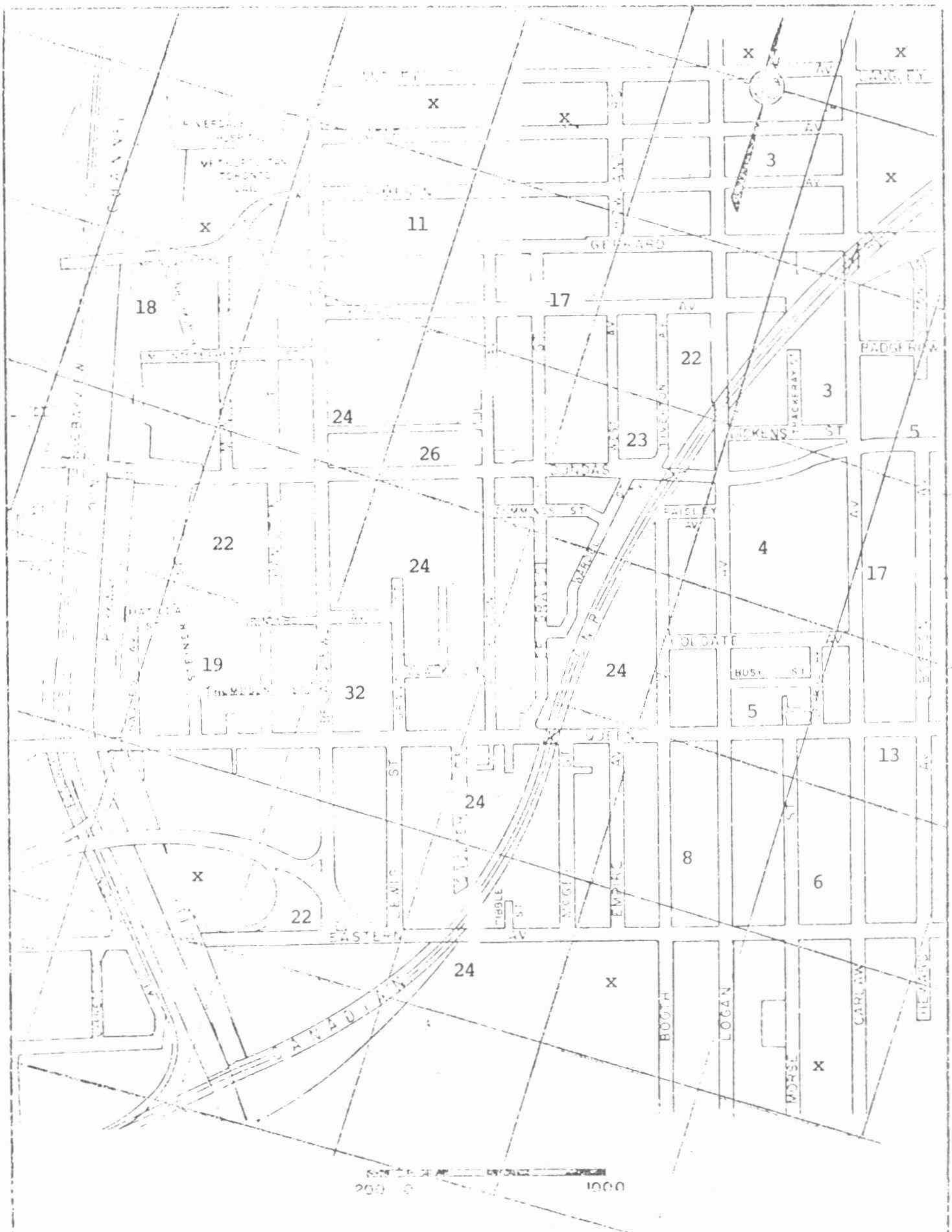


Figure 7.2-7 Control Area - Blood Lead Sampling Locations



x = not computed

Figure 7.2-8 Percentage of Residences "Tested" in the Control Area
(as of May 21, 1974)

TABLE 5.

CONTROL AREA

[illegible]

[illegible]

[illegible]

MALES	0 - 4	5 - 9	10-14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Number Tested	37	228	125	7	1	13	8	1	420
Number 40+	0	0	0	0	0	1	0	0	1
Percentage 40+	0	0	0	0	0	7.7	0	0	0.2
FEMALES									
Number Tested	30	221	139	12	10	24	17	1	455
Number 40+	0	0	0	0	0	1	0	0	1
Percentage 40+	0	0	0	0	0	4.2	0	0	0.2

7.3 Program Description

Previous sections have described the method of blood sampling. Basic information related thereto has been stored on computer tape, eg., age, sex, date of sampling, blood lead level, distance living from lead plant, and patient identification number. Analyses of these data (on approximately 5,000 persons representing about 7,000 blood samples) has just commenced.

Additionally, in-depth epidemiological investigations were undertaken, as were studies of the household environment. Public health nurses conducted epidemiological questionnaires in all households where there was a blood lead level of 40 micrograms per 100 ml of whole blood or greater. In the same households, public health inspectors did an environmental survey including the collection of samples of water, paint, household dust, soil, and other articles as specially indicated. Samples of the questionnaires used in these two investigations are appended. The epidemiological questionnaire and household environmental sampling were also conducted in a neighbouring house where the blood lead levels were less than 40 micrograms per 100 ml of whole blood. In the control area, 150 households are being investigated, all where blood lead levels were below 40, there being very few households in the area where there was a blood lead level above 40. In total, this has involved or will involve investigation of over 500 households, and the collection on the average of a dozen environmental samples per household. These data are being entered on the same computer tape as the basic blood lead data previously described as results are received from the laboratories of the Ministry of Health and the Ministry of the Environment, the whole being geo-coded for ready reference. It is hoped to have this computer in-put completed by September 3, 1974, so that analyses may then be undertaken

and correlated with the community environmental data collected by the Minsitry of the Environment.

CITY OF TORONTO

DEPARTMENT OF PUBLIC HEALTH

EPIDEMIOLOGICAL DATA – LEAD QUESTIONNAIRE PART 1

1. IDENTIFICATION NO.

2. SURNAME

3. GIVEN NAME

4. APT. NO.

5. STREET NO.

6. MOD

7. STREET CODE

8. STREET NAME

9. SEX — MALE / FEMALE

10. BIRTHDATE — D M Y

11. YR. OF IMMIG.

12. BIRTHPLACE

13. CODE

14. PRIMARY OCCUPATION TITLE

15. CODE

16. SCHOOL

17. GRADE

18. SECONDARY OCCUPATION TITLE

19. CODE

20. TELEPHONE No.

21. DATE OF HOME VISIT — D M Y

22. PREVIOUS OCCUPATIONAL LEAD EXPOSURE

Y — IF YES EXPLAIN ON REVERSE

N

UNCERTAIN

NAME OF INTERVIEWER

23. LENGTH OF RESIDENCE AT PRESENT ADDRESS — YRS MTHS

24. LENGTH OF RESIDENCE IN THIS TEST AREA — YRS MTHS

25. LENGTH OF RESIDENCE IN OTHER TEST AREAS (LAST 5 YEARS) — YRS MTHS

26. ADDRESSES FOR PAST 5 YRS OTHER THAN ABOVE

27. DAILY HRS SPENT AT RESIDENCE — HRS

28. DAILY HOURS SPENT WORKING OR AT SCHOOL IN TEST AREA — HRS

29. TOTAL LONG ABSENCES LAST 5 YEARS — YRS MTHS

30. IS THERE A LEAD WORKER IN HOUSE — Y / N

31. IF YES — NAME OF COMPANY

32. OCCUPATION TITLE

33. CODE

34. IS HE/SHE TESTED AT WORK REGULARLY — Y / N

35. IF Y, BLOOD OR URINE — B / U

36. DOES HE/SHE USE PROTECTIVE CLOTHING AT WORK — Y / N

37. ARE WORK CLOTHES CHANGED AT WORK — Y / N

38. ARE WORK CLOTHES WASHED WITH FAMILY CLOTHING — Y / N

39. ARE SHOWERS USED AT WORK — Y / N

40. IS AN ELECTRIC KETTLE USED BY THIS PERSON — Y / N

IF YES

41. HOW MANY CUPS A DAY DOES THIS PERSON DRINK

42. HOW MANY CUPS A DAY ARE USED IN COOKING

43. IS THERE A HISTORY OF ANEMIA — Y / N

44. IS GASOLINE SNIFFING ADMITTED — Y / N

45. CHILD KNOWN TO INGEST PAINT — Y / N

46. CHILD KNOWN TO INGEST SOIL — Y / N

47. OBSERVED SIGNS OF PAINT PICA — Y / N

48. HOW LONG HAS PERSON BEEN SMOKING — YRS

USUAL TYPE OF SMOKING

49. CIGARETTE — 1

50. NO. OF PACKS A DAY — •

51. OTHER — 2

52. STATE TYPE AND QUANTITY

53. HAS PERSON STOPPED SMOKING IN PAST 5 YEARS — Y / N

54. IF Y, HOW LONG AGO — YRS MTHS

55. DO OTHERS IN THE HOUSE SMOKE — Y / N

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CITY OF TORONTO

DEPARTMENT OF PUBLIC HEALTH

ENVIRONMENTAL DATA – LEAD QUESTIONNAIRE PART 2

1. APT No.　2. STREET No.　3. MOD　4. STREET CODE　5. STREET NAME

6. TELEPHONE No.　7. DATE OF INSPECTION (D M Y)　8. INSPECTOR

9. IS THERE A LEAD WORKER IN HOUSE　Y　N

10. IF Y, NAME OF COMPANY

11. OCCUPATION TITLE

12. CODE

13. TYPE OF BUILDING　SEMI　DET　ROW　APT　COMM

14. CONSTRUCTION　BRICK　FRAME　CON-CRETE　STEEL　OTHER

15. CONDITION OF BUILDING　GOOD　FAIR　POOR

16. PAINT PEELING, OR CHIPPING SEEN　Y　N

17. IS FLAKING OF PLASTER SEEN　Y　N

18. WATER SERVICE PLUMBING　COPPER　GAL. IRON　LEAD

19. TYPE OF CENTRAL HEATING　FORCED AIR　OTHER

20. IS THERE A BACK YARD　Y　N

21. IS IT USED BY CHILD AS A PLAY AREA　Y　N

22. TYPE OF SURFACE　GRASS　BARE EARTH　HARD OR GRAVEL

23. HOUSEKEEPING　GOOD　FAIR　POOR

24. DOES HOUSE NEED FREQUENT DUSTING　Y　N

25. IS DUST VISIBLE ON RUGS, FLOORS OR FURNITURE　Y　N

26. HYGIENE　GOOD　FAIR　POOR

27. IS VACUUM OR WET MOP USED MOSTLY　Y　N

28. EVIDENCE OF PAINT PICA　Y　N

29. ARE HOME GROWN VEGETABLES EATEN　Y　N

30. SMALL OR LARGE AMOUNTS　S　L

31. CHECK THOSE EATEN

BEANS	BROC COLI	CAB BAGE	CAR ROTS	CORN	GARLIC	LET TUCE (SALAD)	ONIONS	PEAS
1	2	3	4	5	6	7	8	9
PEP PERS	RAD ISHES	RHU BARB	TOMA TOES	OTHER	SPECIFY			
10	11	12	13	14				

32. WASHED　Y　NOT WASHED　N

33. ARE FRUIT JUICES, ACID STEWS, TOMATOES, ETC., STORED IN CERAMIC, PEWTER, LEAD POTS OR CONTAINERS WITH SOLDER　Y　N

34. IS HOMEMADE WINE OR CIDER MADE OR STORED IN CERAMIC OR PORCELIN AT ANY TIME　Y　N

35. IS THERE A POT OF STEW OR SOUP CONSTANTLY SIMMERING ON THE STOVE　Y　N

36. DOES HOUSE USE CANNED MILK　Y　N

37. IF YES, BRAND NAME AND CODE

38. IS AN ELECTRIC KETTLE USED IN THE HOME　Y　N

39. KETTLE WATER SAMPLE TAKEN　Y　N

40. BRAND NAME

41. MODEL NO.

42. REMARKS:

8. SUMMARY OF FINDINGS AND ABATEMENT RECOMMENDATIONS

8.1 Canada Metal Company Limited

8.1.1 Source and Extent of Lead Contamination

The Canada Metal Company Limited has caused contamination of the environment in the vicinity of its Eastern Avenue plant and, although the operations of the Company continue to add contaminants in excess of proposed criteria, there is an encouraging trend in recent months due to abatement activities. The evidence gathered by the Ministry of the Environment air sampling network and by surveys made of the lead contamination of soil and vegetation demonstrate that Canada Metal is the major source of airborne lead in the area. The traffic on the Gardiner Expressway and on Eastern Avenue as well as sources such as The Commissioners Street Incinerator and Ashbridges Bay Incinerator cause only a negligible rise in airborne lead levels in the area. The major source of the problem at present is not the re-entrainment of contaminated dust and dirt since high suspended lead readings are strongly correlated with winds from the plant.

The proposed Ontario ambient air quality criteria for lead are exceeded for distances of up to 250 feet from Canada Metal. As a result of the operations of Canada Metal, the surface soil is excessively contaminated for distances of up to 1500 feet from the plant and the subsoil to depths as great as 12 inches within 500 feet of the plant.

8.1.2 Degree of Elevation of Blood Lead Level in Canada Metal Area

The preliminary analysis of blood lead sampling data has shown the general population in the vicinity of Canada Metal has experienced a general slight elevation of blood lead level over the average level found in the population in the Control Area. The data show a decrease in blood lead level with distance away from the plant. This was most evident for the pre-school children.

The distribution of elevated blood levels in the areas is scattered with neighbouring houses with similar age children and similar levels of lead in the air, soil, dust, etc., showing a wide variation in blood lead. This would tend to support the hypothesis that inhalation of suspended lead from the air is not the main cause particularly since airborne lead levels beyond 450 feet from the plant are similar to those in the Control Area. Suspended lead levels close to Canada Metal are also showing signs of improvement. The most likely route for lead intake causing elevated blood lead levels in children is, therefore, ingestion.

8.1.3 Recommendations - Canada Metal Company

Based on the evidence available at this time, the Working Group makes the following specific abatement recommendations with respect to Canada Metal in conjunction with the general recommendations for all lead processing companies:

(1) The Company be required to completely enclose the unloading, storage and handling of lead-bearing materials associated with the blast furnace operation, and including, but not limited to the following:

- lead scrap and dross
- baghouse dust
- lead oxide
- slag

(2) The bulk loading and unloading of the lead oxide associated with the lead oxide manufacture be conducted in an enclosed structure such that losses to the environment are prevented.

(3) Backup emission control equipment with alarms be installed on the blast furnace, refinery kettles and the lead oxide plant to ensure that control to meet the standard is maintained in the event of primary control equipment failure.

(4) Stack testing of emissions be conducted by the Company to ensure that the emission meets Ontario standards.

8.2 Toronto Refiners and Smelters

8.2.1 Source and Extent of Lead Contamination

The data collected on lead levels in the vicinity of Toronto Refiners and Smelters demonstrate that levels of lead in the air, dustfall, soil and vegetation exceed proposed criteria and guidelines.

The principal source of these elevated levels continues to be the operations of the Toronto Refiners and Smelters Company.

Suspended lead levels are in excess of the proposed Ontario criteria, to 150 feet from the plant. Dustfall is in excess of the desirable objective for 1000 feet and the soil and undisturbed dust contains excessive amounts of lead for distances up to 1500 feet from the plant.

8.2.2 Blood Lead Levels in Toronto Refiners and Smelters Area

The data show an elevation of blood lead levels in people living near to the Toronto Refiners plant as compared to the Control Area. The incidence of elevated blood lead is more prevalent in children immediately adjacent to the plant.

8.2.3 Recommendations - Toronto Refiners and Smelters

The Working Group on Lead makes the following specific abatement recommendations with respect to the Toronto Refiners and Smelters in conjunction with the general recommendations for all lead processing companies:

(1) The whole of the guillotine penthouse operation, and including battery top separation, plate and grid collection, battery case crushings, and acid collection and neutralization, be conducted in an enclosed building to prevent loss of lead or lead compounds, and of acid, to the outside.

(2) The unloading, movement, and storage of lead-bearing materials be conducted in such a manner that the materials are totally enclosed and losses to the environment are prevented. This includes, but is not limited to the following:

- battery scrap
- furnace slag
- dross
- lead oxide
- baghouse dust
- battery tops

(3) The battery top crushing facilities be completely enclosed, including the charge hopper and other areas as yet unenclosed, but which are a potential source of lead emission.

(4) Backup emission control equipment with alarms be installed on the reverberatory and blast furnace, the melting and refining kettles, and on the battery top separator to ensure that control to meet the standard is maintained in the event of primary equipment failure.

(5) Charging of the reverberatory and blast furnace, and including the skip hoist facilities, be totally enclosed to prevent losses to the environment.

(6) Emissions from the control equipment be directed to a new stack, the height of which is to be governed by land use surrounding Toronto Refiners and Smelters.

(7) Stack testing of all emissions be conducted by the Company to ensure compliance with Ontario standards.

8.3 Prestolite - Summary of Findings to Date

8.3.1 Source and Extent of Lead Contamination

The data indicate that Prestolite has caused lead contamination of the environment to about 1000 feet from the battery manufacturing area. High lead levels measured in early 1974 were strongly correlated with winds from the direction of Prestolite. The airborne lead levels measured during a recent labour dispute which closed down the plant decreased significantly and approached values considered normal for a downtown urban area. Since the plant resumed operations, no large increase in suspended lead levels has been measured. This could be attributed to recent major control measures by the Company which are almost complete.

Suspended lead levels in late 1973 and early 1974 have been elevated for distances of up to 800 feet from Prestolite and dustfall has been in excess of the suggested guideline of 0.3 tons/mile^2/30 days over the same distance.

Levels of lead in soil have been found to exceed the guideline (600 ppm dry weight) for up to 1000 feet from Prestolite with levels over 10,000 ppm in a Company parking lot which has since been paved.

Lead contamination of vegetation was found to be excessive for a radius of about 600 feet from the source.

8.3.2 Blood Lead Levels in the Prestolite Area

A number of people living in the general vicinity of the Prestolite plant have been found to exhibit elevated blood lead levels. The percentage of people with high levels is greater than found in the Control Area.

8.3.3 Recommendations - Prestolite

The Working Group on Lead makes the following specific abatement recommendations with respect to Prestolite in conjunction with the general recommendations for all lead processing companies:

(1) The handling, storage and disposal of lead dross, baghouse dust and any other lead-bearing waste material be conducted in such a manner that the material is wholly enclosed and losses to the environment are prevented.

(2) Backup emission control equipment with alarms be installed on the preparation and assembly operation, the oxide mill-pasting process and on any other operation requiring primary control equipment, to ensure that control to meet the standard is maintained in the event of primary equipment failure.

(3) Stack testing be completed by the Company as planned, on the oxide mill-pasting operation, and in addition, emission testing be conducted on the uncontrolled exhaust from the paste drying ovens. Subject to the results of these tests, further addition of control equipment and/or stack modification be carried out to attain compliance with the standards.

8.4 Tonolli and ESB - Summary of Findings to Date

8.4.1 Source(s) and Extent of Lead Contamination of the Environment

There is considerable evidence that the combined effect of emissions from both the Tonolli and ESB plants has caused and continues to cause severe contamination of the environment in the area surrounding the plants.

The land use in the area is mainly medium and light industrial with two residences very close to the Tonolli plant and a large subdivision to the south some 1500 feet away.

The levels of lead in air, soil and vegetation are some of the highest measured in recent lead surveys, particularly close to the Tonolli plant. Levels in soil and vegetation above the guidelines have been found in part of a residential area to the south of the Queensway.

Although Tonolli and ESB have made significant improvements to their operations, there is, as yet, no evidence of an appreciable reduction in the degree of on-going contamination in the area.

The data from air quality monitoring stations and soil and vegetation surveys all indicate that historically and presently Tonolli is the major source of lead contamination in the area.

Suspended lead levels at all three air sampling locations correlate significantly with winds from the direction of the Tonolli plant and although readings early in 1974 also showed some contribution from ESB, this is now barely detectable.

Particle size data show that the large particles are coming from the Tonolli property and are the main cause of high lead levels close to the plant.

The zones of extreme soil and vegetation contamination are immediately adjacent to the Tonolli plant and lead in dustfall is highest close to Tonolli.

There has been no discernable improvement in the degree or extent of extreme lead contamination near Tonolli since the commencement of monitoring.

Large airborne particles have been measured leaving the Tonolli property. One source of the emissions appears to be the scrap handling and preparation.

Emissions from ESB have contributed to the general lead contamination in the area. The zone of contamination of soil and vegetation is extended eastwards around the ESB plant and above normal suspended lead levels have been measured 200 feet from ESB with winds from the plant to the sampler.

8.4.2 Recommendations - Tonolli and ESB

The Working Group makes the following specific abatement recommendations with respect to Tonolli and ESB in conjunction with the general recommendations for all lead processing companies:

(1) Storage and handling of all lead-bearing materials at Tonolli, and including, but not limited to, lead dross, crushed batteries, lead grids, and plastic from crushed batteries, be conducted in such a manner that the material is totally enclosed and losses to the environment be prevented.

(2) Preliminary battery crushing at Tonolli be conducted in a totally enclosed system such that emissions to the environment are prevented. The practice of unloading batteries from elevated trucks by dumping on the ground be discontinued.

(3) Backup emission control equipment with alarms be installed at Tonolli on the lead refining process and on the rotary battery crusher. Alarms to also be installed on existing control equipment.

(4) Subject to results of stack tests to be conducted by Tonolli, the use of the existing 200-foot stack be reconsidered in order to meet standards.

(5) The handling, storage and disposal of lead dross, baghouse dust, lead oxide and any other lead-bearing material at ESB Canada be conducted in such a manner that the material is wholly enclosed and losses to the environment are prevented.

(6) Backup emission control equipment with alarms be installed at ESB on the oxide mills, the MAC machine, and on the miscellaneous pro-

cessing operations. Primary control equipment with alarms and backup control equipment with alarms be installed on the six (6) operations as committed by ESB on February 7, 1974.

9. ON-GOING AND PROPOSED PROGRAMS

9.1 Environmental Sampling - 1974 On-Going Programs

In 1974 the Ministry of the Environment of Ontario will conduct lead sampling at some 20 locations in the Province and in addition will undertake preliminary sampling at a further 8.

The main efforts of the program are directed towards the Central Region which is comprised of Metropolitan Toronto, York, Peel, Halton, Ontario and Durham Counties.

In this area, comprehensive sampling of air, dustfall, soil and vegetation for lead is being conducted at 11 locations and in addition samples are being collected near highways and adjacent to downtown streets.

The main program is shown in Tables 9.1-1 and 9.1-2. The purpose of this program is not to provide a direct link with blood lead sampling but to determine the extent of environmental lead contamination.

9.1.1 Suspended Lead - Central Region

Suspended lead in air is being measured by a network of 21 special hi-volume sampling stations of which 15 are situated in the vicinity of the five plants covered in this report. The 15 sampling stations operate on a continous basis 24 hours a day, 7 days a week.

In addition the particle size distribution of the suspended particulate lead is measured every other day at three sites adjacent to Canada Metal, Toronto Refiners and Tonolli.

In the next few months 3000 selected samples will be analyzed to determine the lead/bromine ratio and obtain an estimate of the automotive contribution to the total suspended lead level.

9.1.2 Dustfall - Central Region

The fallout of settleable lead-bearing particles will be monitored by collecting 30-day samples at 32 locations of which 25 are in the vicinity of the five plants and the Control Area discussed in this report.

The dustfall will be analyzed to determine the content of other heavy metals and trace materials.

9.1.3 Soil and Vegetation - Central Region

In 1974 it is anticipated that 940 station visits will be made and 5350 samples of soil and vegetation collected for lead determination. In the area discussed in this report, 800 collections will be made and some 4500 samples collected.

The soil samples will provide more data on the extent and depth of contaminated soil round the lead processing companies and at other locations such as adjacent to streets and highways.

Table 9.1-1

1974/75 LEAD PROGRAM (CENTRAL REGION)

COMPANY	OBJECTIVE(S)	RESOURCES REQUIRED TO MEET OBJECTIVE(S)						
		AIR QUALITY		PHYTOTOXICOLOGY			TECH. DEV.& APPRAISAL	
		HI-VOL	DUSTFALL	SOIL	VEGETATION	OTHER	MOBILE MONITOR	STACK SAMPLING
Canada Metal Company, Toronto.	a) Relate Air Quality & soil & vegetation lead levels to blood lead data (at current level) b) Examine trends in air qual., soil & vegetation levels after control equipment operating. c) If no improvement in (b), determine sources of emissions.	4 daily 1 Anderson Lead for particle size.	4 monthly	monthly March - October	monthly March - October	Snow Fruit & Vegetable	Mobile Van April'74 3 day survey	None by Ministry
Toronto Refiners & Smelters, Toronto.	a) Determine cause of continuing elevated levels. b) Examine trends in air quality, vegetation & soil lead levels.	2 daily 1 Anderson	9 monthly	monthly March - October	monthly March - October	Fruit Vegetables 10 Stations.	LIDAR Survey under contract.	None by Ministry
Prestolite	a) Determine trends in air quality & vegetation when control equipment operational. b) Check compliance with air quality objectives.	2 daily	2 monthly	monthly March - October	monthly March - October	Fruit Vegetables 10 Stations.	-	None by Ministry
Urban Control Area	a) Determine background lead levels in air, soil and vegetation.	3 daily 6 months	3 monthly only	2 collections	2 collections	-	-	None by Ministry
Tonolli and ESB, Mississauga.	a) Determine source of lead levels (ESB or Tonolli). b) Determine effect of control at ESB & Tonolli. c) Examine trends.	3 daily 1 Anderson	9 monthly	Monthly March - October		Fruit Vegetables	Resurvey	No
Dominion Colour and Anaconda	a) Determine cause & degree of lead & cadmium levels. b) Determine effect of Control Programs.	2 daily	2 monthly	2 Collections		-	-	-
General Motors Oshawa.	a) Determine lead levels in area.	3 daily 2 Hi-Vols. 6 months	1 monthly	2 Collections		-	-	-
Federated Genco, Scarborough.	a) Determine if lead levels are elevated in area.	2 daily 6 months	2 monthly	2 Collections		-	-	-

Table 9.1-2

LEAD PROGRAM - AIR RESOURCES BRANCH

Level of Service at Oct.1/73 & Proposed Expansion to Oct.1/74

COMPANY	AIR QUALITY SAMPLING PROGRAM NO. OF STATIONS ON DATE SHOWN								PHYTOTOXICOLOGY PROGRAM					
	Oct.1/73		Mar.31/74		Oct.1/74		Increment from Oct/73		1973-74		1974-75 Proposed		Increment	
	Hi-Vol	Dustfall	HV	DF	HV	DF	HV	DF	Stations Visited	Samples	Station Visits	Samples	Station Visits	Samples
Canada Metal	1 every 2 days	2	4 daily + 1 Anderson	4	4 daily + 1 Anderson	4	+3	+2	72	360	272	1,680	200	1,320
Toronto Refiners	2 every 2 days	7	2 daily + 1 Anderson	9	2 daily + 1 Anderson	9	-	+2	70	360	130	780	60	420
Prestolite	0	0	2 daily	2	2 daily	2	+2	+2	20	105	150	840	130	735
Control Area	0	0	3 daily	5	3 daily	5	+3	+5	47	94	100	600	53	506
Tonolli and ESB	1 every 2 days	3	3 daily + 1 Anderson	9	3 daily + 1 Anderson	9	+3	+6	44	64	160	930	116	866
Dominion Colour & Anaconda	0	0	2 daily	2	2 daily	2	+2	+2	-	-	40	160	40	160
General Motors, Oshawa	0	0	1 every 7 days	1	1 every 3 days	1	+1	+1	15	60	30	120	15	60
Federated Genco, Scarborough	0	0	2 daily	2	2 daily	2	+2	+2	8	12	24	96	16	84
Goodyear, Collingwood	0	0	1 every 2 days	0	1 every 2 days	0	+1	0	8	16	12	48	4	32
Corning Glass, Bracebridge	0	0	2 daily	0	2 daily	0	+2	0	15	72	20	80	5	8
ESB, Scarborough	0	0	1	2	0	0	-1	-2	5	7	6	24	1	17
TOTALS - Central Region	4 every 2 days	12	23 + 3 Andersons	34	21	32	+17	+20	304	1,150	944	5,358	640	4,209
Ethyl Corporation, Sarnia	0	0	2 daily	-	2 daily		+2		5	15	12	48	7	33
EMCO, London	0	0	2 daily	-			+2		-	-	15	60	15	60
Chrysler Corp., Windsor	-	-	-	-	-	-	-	-	13	26	12	48	-1	22
Prestolite Battery, Sarnia.	-	-	-	-	-	-	-	-	6	18	10	40	4	22
North American Containers, Aylmer	-	-	-	-	-	-	-	-	12	24	12	48	0	24
TOTALS - South-West Region	0	0	4	-	4	-	+4	-	36	83	61	244	25	161
Ram Refined Alloys	-	-	-	-	-	-	-	-	13	13	10	40	-3	27
Crane Canada	-	-	-	-	-	-	-	-	12	36	12	48	0	1
True Temper	-	-	-	-	-	-	-	-	15	43	12	48	-3	0
United Smelting & Refining	-	-	-	-	-	-	-	-	12	44	12	48	0	4
Gould Batt	0	0	1 every 6 days	0	1 every 6 days	0	+1		15	60	15	60	0	0
TOTALS - West-Central Region									67	201	61	244	-6	43

9.1.4 Source Testing

The Ministry of the Environment will in the next few months complete a program of testing of emissions from selected lead sources for the purpose of obtaining information to permit an assessment of the effectiveness of various control measures.

In addition, three lead companies have, under Ministry supervision, completed compliance testing of emissions as part of their abatement activities. It is anticipated that Canada Metal, Prestolite, Electric Storage Battery Co., Mississauga, and Tonolli will also undertake compliance tests under Ministry supervision in the fall of 1974.

9.1.5 Special Studies

The Ministry of the Environment is at this time developing air sampling techniques to enable simultaneous upwind/downwind 30-minute and 1-hour suspended lead samples to be taken. The field testing of the method is almost complete and the results appear very promising and the correlation with other methods good.

9.2 Blood Lead Sampling and Collection of Epidemiological Data

9.2.1 City of Toronto Board of Health Programs

At this time (July 1, 1974) blood lead sampling programs have been conducted as shown in Table 9.2-1.

TABLE 9.2-1

Summary of Blood Lead Sampling to July 1, 1974

Area	Number of Persons Tested
Canada Metal	1500
Toronto Refiners and Smelters	250
Prestolite	2000+
Control Area	1300
TOTAL	5050

9.2.2 Epidemiological Questionnaire and Retest Program

Of those tested about 200 persons were found to have a blood lead level in excess of 40 ug/100 ml. A detailed questionnaire has been completed for each person with a level over 40 ug/100 ml dealing with home environment, occupation, child behaviour, etc. For each house under study two control houses have also been studied. Sampling of the lead in the home environment has been conducted in each set of three houses.

In addition, persons having a blood lead level of over 40 ug/100 ml have been retested as soon as possible and if confirmed have been sent to Sick Children's Hospital, Toronto, for further investigation. Twenty-three children have been admitted for study and treatment.

9.3 Analysis and Assessment of Data Gathered in 1973/74

During programs carried out by the Ontario Ministry of the Environment, the City of Toronto Department of Public Health and the Ontario Ministry of Health in 1973/74, suspended lead samples, dustfall samples, soil and vegetation samples, blood lead samples and samples of dust, paint, water, etc., have been collected.

The Working Group on Lead has undertaken to oversee the task of creation of a computer data bank of the information and to assign the task of creating a lead data analysis system to the Ontario Ministry of Government Services Systems and E.D.P. Branch.

The estimates are that the system will be ready to run by about October 1974 and that the major portion of the analysis will be complete by the end of the year.

The Working Group intends to call on the services of expert consultant on both the design and assessment stages.

9.3.1 Creation of Data Bank

The first objective will be to create a computerized data based comprised of seven basic files:

(a) High-Volume Sampler Data

(b) Anderson Head Data (Particle Size Distribution)

(c) Dustfall Data

(d) Meteorological Data

(e) Phytotoxicology Data (Soil and Vegetation)

(f) Health Data (Blood Lead Levels)

(g) Epidemiological Data (Habits, Behaviour, etc.)

(h) Epidemiological Data (Lead in Dust, Paint, Tapwater, etc.)

It is anticipated that these files will be created by the Ontario Ministry of the Environment (a - e) and the City of Toronto Department of Public Health and the Ontario Ministry of Health (f,g,h) by mid-September 1974.

The data files will be maintained by the respective agencies.

9.3.2 Analysis and Cross-Correlation of Environmental, Epidemiological and Blood Lead Data

The data analysis system will permit the correlation and regression of the data on any file with basic parameters such as distance, direction, age, etc.

The system will also allow the more important correlations and multiple regressions between the data on one file and that on another whilst holding one or more of the basic parameters (distance, etc.) constant.

The system will be written in a general way and at this time only certain multiple regressions can be foreseen. Further analysis will depend on the results obtained in the initial stages.

9.3.3 Interpretation of Assessment of Statistical Results

The interpretation of the statistical correlations will be very complex due to the many variables involved. The Working Group will draw heavily on experts in the field to assist with the assessment of the data.

It is anticipated that if the data are sufficient the following types of relationships may be found if these in fact exist:

- Relationships between blood lead level and distance and direction from the source;
- Determination of the pathway(s) of lead intake by humans (dust, dirt, soil, paint, tapwater, etc.);
- Determination of high risk group and behaviour traits increasing the risk of lead absorption;
- Relationships between soil and vegetation contamination and airborne lead levels.

9.3.4 Cost of Analysis and Assessment

The cost of file creation and data analysis has been estimated at $45,000 by the Ontario Ministry of Government Services.

The cost of assessment using consultants is difficult to predict but a figure of $50,000 based on 30 days at $1500 per day plus expenses may be used as a guide.

The costs of file maintenance will be borne by each separate agency involved and are not available.

9.4 Recommendations for Future Blood Lead Sampling Programs

9.4.1 Report of Medical Subcommittee of Working Group on Lead

On Monday, June 17th, the Medical and Environmental Subcommittees of the Working Group on Lead met with Dr. Carnow and Dr. Chisolm in the 10th floor boardroom at 135 St. Clair Avenue.

The following people were present:

Dr. Linzon,	Ministry of the Environment
Dr. Shenfeld,	Ministry of the Environment
Mr. Trivett,	Ministry of the Environment
Dr. Anderson,	University of Toronto
Dr. Parkinson,	Hospital for Sick Children
Dr. Stopps,	Ministry of Health
Dr. Higgin	Ministry of the Environment
Dr. Chisolm,	Johns Hopkins University
Dr. Carnow,	University of Illinois
Dr. Levy,	University of Illinois
Dr. Wadden,	University of Illinois
Dr. Moss,	City of Toronto
Dr. Mitchell,	City of Toronto

The first portion of the meeting was devoted to the epidemiologic aspects of the Toronto Lead Study which were reviewed by Dr. Moss and Dr. Mitchell.

About 5000 persons have had one or more blood samples taken for lead analysis. The sampling areas are Toronto Refiners and Smelters Limited,

Canada Metal Limited, Prestolite Battery Division of Eltra of Canada Limited and the Control Area. Of those sampled roughly 200 have had blood lead levels of 40 micrograms per 100 ml whole blood or more. Most of these 200 have been referred for further workup by the Hospital for Sick Children; approximately 23 children were admitted to hospital. Most are children. There are a small number of adults.

A detailed questionnaire has been filled in for each person with a blood lead over 40 micrograms. This questionnaire deals with such matters as housing, occupation, child behaviour, etc. For each such house with a blood lead value above 40, usually two matching control houses are studied. One of these controls is a person from a nearby house who has a blood lead level under 40 while the second control also has a blood lead level under 40 from a house in a similar area.

Household environmental studies have been conducted, samples of paint, water, dust, soil, etc., having been sent to provincial laboratories for analysis.

It is hoped to have all the epidemiological and household environmental data stored in "cleaned" form on magnetic tape by September 3rd at which time the data processing can begin.

A discussion then took place over the desirability of a random sample of 5000 children across the whole City of Toronto and it was agreed that in the light of the studies already carried out that environmental measurements of

the lead in soil and air provide excellent clues to the areas in which high blood lead levels might be expected and that the chance of random blood sampling picking up a hitherto unknown source is remote. This, of course, does not mean that sporadic blood lead values above 40 will not be found remote from local sources such as lead smelters but the factors accounting for such blood lead levels are probably due in part to factors in the "mini environment" (lead levels in household dust, age and sex of residents, personal behaviour, etc.).

It was agreed that areas of the City would be picked on the basis of such considerations as socio-economic factors to provide a useful comparison with those already sampled and that within each area random sampling would be carried out after an intensive information campaign.

To enable the study to concentrate on the most productive areas, it was felt that emphasis would be reduced on children aged 5 - 15 in favour of more effort directed to sampling the few-months-old to 4-year-old group.

Because the data now available suggests that blood lead and soil lead levels have reached "background" levels within one-half mile radius of the lead plants, the original one mile radius sampling area would be reduced to one half mile. This provides a more compact geographic area which can more easily be reached by information campaigns and door-to-door canvasses.

It is estimated that the number of children under age 5 years available for sampling within one-half mile of the lead plants is about 3,500 and that a further 3,500 under age 5 would be sampled in control groupings. The basis for picking these

control groups is to be discussed by mail with each group or person sending in an opinion to Dr. Stopps. This will require screening approximately 7,000 children, and the subsequent intensive epidemiological follow-up of approximately 1000 of these. It is inevitable that other children will present themselves for testing and cannot be turned away. This eventually could add another 1000 or more persons to the screening procedure. It was pointed out that in order to conduct the field operation of a study of this magnitude, the Department of Public Health of the City of Toronto will require funds from the Province.

With regard to the effect of hemoglobinopathies, it was agreed that the available methods for detecting such conditions as Glucose-6-phosphate dehydrogenase deficiency and thallasemia would be looked into by Dr. Parkinson and a report prepared on the feasibility of screening studies for the hemoglobinopathies.

Because F.E.P. (free erythrocytic protoporphyrin) screening offers certain advantages over screening by blood lead determination, Dr. Chisolm will forward a copy of his method using micropipettes together with a short statement on the advantages and disadvantages of F.E.P. screening.

Lastly, it was agreed that the questionnaire used in the study would be circulated by Dr. Mitchell and comments sent to him with a copy to Dr. Stopps.

In conclusion, this was a worthwhile and productive meeting which together with the conclusions of the Sub-committee considering environmental measurements should lead to a more soundly based study of the factors influencing blood lead levels in Toronto children. Further meetings will be necessary to spell out further details of the study but the next important step will be the setting down of a

detailed protocol for phase one of the study - that portion dealing with the populations around the three lead plants and in the control area. As soon as this protocol has been set down and circulated, a further meeting of the sub-committee will be necessary to decide on Phase 2 - that portion of the study involving the second and third control areas. At this time decisions will be necessary on the statistical treatment of data and the provisions to be made for data processing.

9.4.1.1 Cost of Program

An extended study as recommended by the Medical Subcommittee will require supplementary funding of the order of $151,800 to carry the field study. Consultants' fees and data processing would be extra.

9.4.2 Supporting Environmental Programs Design and Approximate Costs Report of the Environmental Sub-committee of The Working Group on Lead, Meeting of June 17, 1974 with Consultants on Lead Program

Present:

Dr.Julian Chisolm	John Hopkins University Faculty of Medicine, Baltimore
Dr.B.W. Carnow)	University of Illinois School of Public Health
Dr. Levy)	Institute of Environmental Medicine Chicago
Dr.R. Wadden)	
Dr.G.J. Stopps	Senior Medical Consultant, Community Health Standards Div. (MOE)
Dr.G.W. Moss	Department of Public Health City of Toronto
Dr.J. Mitchell	Department of Public Health City of Toronto
Dr.T.W. Anderson	School of Hygiene, Faculty of Medicine University of Toronto
Dr.T. Parkinson	Toronto Board of Health and Sick Children's Hospital
Mr.L. Shenfeld	Air Resources Branch, MOE
Dr.S.N. Linzon	Air Resources Branch, MOE

Dr.R.M.R. Higgin	Air Resources Branch, MOE
Mr.G.S. Trivett	Field Services Division, Industrial Abatement (MOE)

Environmental Data:

A brief review of existing Environmental sampling data was presented.

It was agreed that the present network was adequate for the purpose it was intended for but it was not specifically designed to coordinate with blood lead sampling, and that in future, studies in environmental sampling should be expanded to give more close coordination with blood lead sampling programs.

This would mean a maximum of about 20 extra hi-volume sampler stations and probably 3 areas for soil and vegetation sampling of a similar size to the present Control Area.

In addition, it was indicated that present air quality data supplemented by model predictions would be made available for design of the random screening program. Soil and vegetation data would also be used to assess environmental lead levels in the City of Toronto.

Recommendations of the Environmental Subcommittee:

1. The Ministry of the Environment, in addition to maintaining its present intensive sampling around the lead plants. closely support future blood lead sampling programs by monitoring the air, soil and vegetation in the areas selected.

2. The Ministry assist in selection of areas for blood lead sampling programs by determining areas of high, moderate and low lead levels using existing air quality data and computer modelling in other areas.

3. That Dr. Carnow and his group be given the opportunity to participate as consultants in the program design and assessment.

Cost Estimates of Recommendations:

1. Additional Monitoring in Support of Blood Lead Sampling Program

Extra Equipment Capital Cost (20 Stations) 40 hi-volume samplers @ $300 each	$ 12,000
Operating & Analysis Costs - 3 month survey 20 stations hi-volume at $1,000/month	60,000
Dustfall 20 stations at $64/month	4,000
Soil & Vegetation (including analysis) 100 stations (2 collections) @ $170 per collection	34,000
Total Sampling Costs	$110,000

2. Assessment of Present Lead Levels in Toronto

a) Review of existing air quality data	-
b) Modelling of Lead in Toronto (estimated)	3,000

3. Program Design Using Consultants

Estimated 3 days at $1,500 per day	4,500

4. Computer Analysis & Assessment Using Consultants

1. Data Analysis Only Estimated on basis of Ministry of Government Services cost	40,000
2. Assessment and Interpretation Only Relationship between lead in the environment and health	50,000

Total Cost Over and Above Present Program

Sampling and Monitoring	$110,000
Modelling	3,000
Total Direct Ministry Expenditure	113,000
Analysis & Assessment*	90,000
TOTAL	$203,000

* This cost is the incremental cost for the expanded study with Dr. Carnow's group participating as consultants. Computer Analysis has been estimated at about $40,000 by Ministry of Government Services.

NOTE: The analysis of blood lead data is included in the analysis and assessment costs, but cost of conducting the blood lead sampling program is not included in the sampling/monitoring cost estimate.

TECHNICAL TERMS

ALA	-	aminolaevulinic acid
ALAD	-	aminolaevulinic acid dehydratase
arithmetic mean	-	average of a set of readings ie $\frac{\text{sum}}{\text{number}}$
baghouse (bag collector bag filter)	-	air pollution control device for removal of particles from a gas stream with fabric bags
correlation	-	statistical relationship between 2 variables
correlation coefficient	-	parameter indicating strength of statistical relationship between two variables
criterion	-	maximum desirable level of a pollutant in air based on health or other effect
dross	-	solid metallic surface layer of molten metal containing impurities
fume	-	finely divided particles in a gas
geometric mean	-	median value with 50% of the readings above the value and 50% of the readings below
guideline (desirable objective)	-	tentative desirable level of a pollutant in the environment. Used where there is insufficient evidence for proposal of criterion and standard
hivol	-	hivolume sampler for measuring fine particles in air
isopleth	-	boundary line of a zone having the same values
M.M.E.D.	-	Mass median equivalent diameter (the geometric mean size of a group of particles expressed in terms of equivalent spherical diameter)
Pasquill-Gifford diffusion equation	-	Mathematical equation used to predict the dispersion of stack plumes
pH	-	measure of acidity or alkalinity of a substance
pica	-	ingestion of non-food items
tetraethyl lead	-	organic lead antiknock component added to gasoline to increase the octane rating

MEASUREMENT UNITS

lead in air	-	micrograms per cubic metre - ug/m^3
lead in dustfall	-	tons per square mile per 30 days - tons/mile^2/30 day grams per square metre per 30 days g/m^2/30 day
lead in water		micrograms per [illegible] micrograms per [illegible]
lead in soil	-	parts per million dry weight ppm micrograms per gram ug/g
lead in blood	-	micrograms per 100 millilitres of blood ug/100 ml
particle size	-	micrometres (millionths of a metre)-um